Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **2007**	2. REPORT TYPE	3. DATES COVERED **00-00-2007 to 00-00-2007**

4. TITLE AND SUBTITLE **Supporting training strategies for brigade combat teams using Future Combat Systems (FCS) technologies**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) **Michael Shanley; James Crowley; Matthew Lewis; Ralph Masi; Kristin Leuschner**	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **RAND Corporation,1776 Main Street,Santa Monica,CA,90401-3208**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) **Captain James Malcom, HQ USAF/A8XP, Room 4D1083, 1070 Air Force Pentagon, Washington, DC, 20330-1070**	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

Document no.: RAND/MG-538-A Online access http://www.rand.org/pubs/monographs/MG538/ Additional authors: Straus, Susan ; Angers, Jeffrey P.

14. ABSTRACT

This study seeks to help the Army identify options to improve its future (i.e., circa 2016) training strategies for Brigade Combat Teams (BCTs) equipped with Future Combat System (FCS) technologies. Key findings are that live training will need to remain at the core of training programs for FCS units, and that adaptation to changing operational requirements will be a primary training challenge. Overall, the findings indicate that planned training enhancements can provide important improvements across a wide spectrum; however, the overall training capability achieved will likely be less than that needed to meet future training requirements. Unit time, the potential for technological advancement, and training budgets were found to be key constraints. While the study stresses greater emphasis on training manpower support in battle command training as the Army's best chance for significant near-term improvement, it concludes that longer-term improvement will depend on how closely the Army monitors and manages its enhancement programs. The process of shaping and balancing future training enhancements, for example, would benefit from better information and improved evaluative capabilities. These changes would be further enhanced by developing better metrics for the quality, quantity, and adaptability of training, by continuing to improve spiral development processes to evolve training methods and means, and by improving the visibility of financial information across training categories.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**303**	

This product is part of the RAND Corporation monograph series. RAND monographs present major research findings that address the challenges facing the public and private sectors. All RAND monographs undergo rigorous peer review to ensure high standards for research quality and objectivity.

Supporting Training Strategies for Brigade Combat Teams Using Future Combat Systems (FCS) Technologies

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Prepared for the United States Army
Approved for public release; distribution unlimited

RAND ARROYO CENTER

The research described in this report was sponsored by the United States Army under Contract No. W74V8H-06-C-0001.

Library of Congress Cataloging-in-Publication Data

Supporting training strategies for brigade combat teams using future combat systems (FCS) technologies / Michael G. Shanley, [et al.].
p. cm.
Includes bibliographical references.
ISBN 978-0-8330-4020-6 (pbk. : alk. paper)
1. Soldiers—Training of—United States. 2. Military education—United States. 3. United States. Army—Reorganization. I. Shanley, Michael G., 1947–

U408.3.S86 2007
355.5'2—dc22

2006100819

Published 2007 by the RAND Corporation
1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
4570 Fifth Avenue, Suite 600, Pittsburgh, PA 15213-2665
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Preface

In the years and decades to come, maneuver brigades equipped with Future Combat Systems (FCS) technologies will face complex and wide-ranging operational challenges. To continue to be successful, training strategies must be capable of rapid evolution and be designed to provide comprehensive support for mission and training requirements generated by changing operating environments, evolving advanced organizational and operational concepts, and emerging joint warfighting imperatives. This report provides the results of a project designed to identify options for improving support to the Army's future training strategies for Brigade Combat Teams (BCTs) equipped with FCS technologies. The work was sponsored by the Unit of Action Maneuver Battle Lab (UAMBL) within the Army's Training and Doctrine Command.

This study first identifies increases in future Army training requirements balanced against current training capabilities. It then assesses an array of planned enhancements designed to support the future Army training strategy, and identifies gaps between requirements and likely achievements. Finally, the study analyzes ways to address the gaps found and recommends actions that should be given priority in the next round of resourcing decisions. The work will be of interest to those involved in training development, training strategies for maneuver units, training system integration, and training transformation. Outside of the training realm, this report will be of interest to researchers involved in force readiness, technology assessment, and acquisition.

The research was carried out in RAND Arroyo Center's Manpower and Training Program. RAND Arroyo Center, part of the RAND Corporation, is a federally funded research and development center sponsored by the United States Army. The Project Unique Identification Code (PUIC) for the project that produced this document is DAPRRY007.

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Summary

The U.S. Army is adapting its organizations, operational concepts, and systems to meet the needs of the current demanding security environment while also maintaining a focus on the changes needed to transform over the longer term. Ongoing and future challenges include frequent deployment rotations, a more adaptive enemy, and an expanded array of missions. Others include the need to rapidly transition from combat operations to stability operations and support operations (SOSO), the increased use of joint and combined arms capabilities at lower echelons, more self-contained and leaner unit designs, and the continuing introduction of new technologies. These changes are placing increased demands on the Army's collective and leader training programs now, and these demands could increase in the future. Future training will need to provide soldiers at all grade and experience levels with sufficient technical expertise to use new systems as well as the complex skills necessary to achieve mission success; training will also need to cover a larger range of skills and adapt quickly to changing needs and conditions. Training must help units achieve readiness quickly and sustain higher levels of readiness over time. All this must be achieved, moreover, despite constraints on training resources.

This study seeks to help the Army address these challenges by identifying options for improving support to the Army's future training strategy for Brigade Combat Teams (BCTs) equipped with Future Combat Systems (FCS) technologies. The project seeks to assess the effectiveness of future planned enhancements to the Army's capabilities to train FCS-equipped BCTs in light of future training requirements, and to identify key improvements to training capabilities that

the study's sponsor, the Unit of Action Maneuver Battle Lab (UAMBL), might champion to increase the effectiveness of the emerging training strategy. The study focused chiefly on leadership training rather than soldier skills because leadership decisionmaking will be increasingly important for the future force, including lower echelons.

Challenges for Current Army Training Strategies

To establish a baseline, we first examined the content and output of current training programs. We used this information to determine the training that units were able to conduct, constraints on training programs, and areas in which current training could be improved. The results reveal a highly effective training system but also point to enduring challenges. For example, units have had difficulty completing the recommended number of training events. A study of BCT training programs in 2001 and 2002 found that units did significantly fewer events than recommended in the Tank Battalion Combined Arms Training Strategy (CATS). Similar results were found for leader training exercises. Moreover, relatively few virtual and constructive simulation exercises were performed at home station. Similar findings emerged across maneuver unit types and for training programs in the post-OIF period, where time was an even greater constraint.

Despite completing fewer events, units appeared to have achieved reasonable proficiency across many skill areas once a CTC rotation was completed. Research consistent with this conclusion was reported for units in the pre-OIF period, supporting the contention that the Army's training system has been fundamentally sound.

However, despite overall success, this same research shows that most units are not as successful at achieving collective training proficiency at the battalion and brigade levels as they are at the platoon and company levels. Moreover, adequate levels of proficiency were not reached by most units even at the NTC in some significant skill areas, including synchronization and intelligence-surveillance-reconnaissance (ISR), which are important to achieving the full potential of modular operational concepts and modernization of command, control, communications, computers, and ISR (C4ISR).

Future Training Requirements

We also examined the organizational designs and operational concepts of FCS-equipped BCTs, as well as the ARFORGEN training strategy, to identify specific areas in which training requirements could become more challenging. We concluded that all three concepts lead to a need for the training system to continually evolve and adapt. The evolving ARFORGEN training strategy implies a need for training to better cover the full spectrum of operations. Transformational initiatives including modernization, modularity, and lifecycle manning are all likely to change training requirements. For example, modernization will increase the number of systems requiring operator training and may add to system technical requirements (e.g., for C4ISR equipment), thus necessitating more complex skills training. Modularity will add to the BCT's menu of functions and tasks that were formerly performed at division level and by separate specialty units. Moreover, the greater number of brigades will increase competition for maneuver areas and ranges. Perhaps of greatest consequence to the training system, the ongoing evolution of Army transformation makes predicting the effects of transformational initiatives on training and readiness requirements an uncertain and ambiguous process.

Assessment of Training System Enhancements

The Army has set targets for large improvements to the training system as applied to BCTs equipped with FCS systems. The goals of the improved training system include significantly shorter timelines to achieve readiness and high standards on maintaining that readiness; the capability to address a much wider range of conditions in the operating environment; and the synchronization of a much wider range of information systems and other technologies in an expanded battle space. To achieve these goals, the Army has proposed a set of training system enhancements. In this study, we assessed the potential value of 12 types of enhancements for training at brigade level and below in the 2010–2016 timeframe (see Table S.1).

To assess the planned enhancements, we first evaluated each individual enhancement in Table S.1 against three key metrics:

- **Training quality.** The potential of the enhancement to increase the desired training effect, as determined by increased training event realism, complexity, and feedback.
- **Quantity of training events.** The potential of the enhancement to increase the number and duration of training events or the number of soldiers or leaders trained.
- **Adaptability of training events.** The potential of the enhancement to allow training events to be adapted to a wide range of missions, enemies, conditions, and other considerations.

In addition, the benefits of each enhancement were evaluated in relation to "limiting factors," including constraints on unit time, technology risk (of being able to provide an affordable capability within the period), and the risk of less than full funding for the entire capability envisioned.

Table S.1
Planned Enhancements for Training

Category of Enhancement	Enhancements Evaluated
Live Training	• Live training technologies • Maneuver CTC-specific enhancements
Simulation-Supported Training	• Constructive • Virtual • Simulation-based leader tactical skills trainers
Integrating Enhancements for Training	• Embedded training • Live-virtual-constructive (LVC) training integration and tools • Training manpower support (home station)
Other	• Lifecycle manning • Institutional training initiatives • Collective training support products • Initial fielding of BCTs equipped with FCS

To assess the aggregate value of the enhancements as well as the balance of investment across categories, we first bring together the individual assessments of the enhancements to present a summary view of benefits in terms of their contribution to improving the quality, quantity, and adaptability of training. To complement the broader look, we also provide a more focused comparative assessment of enhancements in the context of two substantive areas: training of battle command skills and training requirements of Army modernization. Finally, we examine aspects of the Army's budget process with regard to training enhancements and the process's ability to facilitate tradeoff decisions in a resource-constrained environment.

Assessment of Individual Training Enhancements

Assessments of each enhancement area appear below. The evaluations were based on reviews of various requirements documents, discussions with training and materiel developers as well as Army staff responsible for training funding programs, and the experience of RAND staff members working in related areas.

Enhanced Live Training Technologies. All the live enhancements offer some potential to improve the quality of training. We conclude that improving the live capabilities is critical because live training will remain the cornerstone of maneuver unit training. Especially important are initiatives to increase the realism of close-in live-fire engagements and MOUT (military operations on urban terrain) facilities. The only potential improvement for training quantity comes from the increased number of live-fire ranges and MOUT facilities, but given the costs of these facilities and limitations on training area size, this benefit will be achieved slowly.

Maneuver CTC-Specific Enhancements. The CTCs have been critical components of maneuver training programs, and we think this will continue. Enhancements do not affect the quantity metric there, as they do not affect throughput. However, we do see some improvement in terms of quality. The instrumentation and maneuver area enhancements can help the CTCs effectively train modular, modernized BCTs in the contemporary operating environment (COE). This is especially important considering the increased difficulty of conducting such training at home stations. The ability of the CTCs to maintain event quality and a capability to adapt events will depend on maintaining an adequate level of training manpower support for the CTCs. In the past, the CTCs have proven capable of effective adaptation due to the capabilities of their trainers and opposing force (OPFOR). Additionally, the enhancement of the CTC MOUT training capabilities will benefit adaptation.

Constructive Battle Command Simulations. The OneSAF and WARSIM technologies[1] by themselves will provide limited improvement in training quality and adaptability. While the technologies will provide quality improvements in some areas (e.g., the physics of realistic MOUT combat), limitations in SAF in the 2016 timeframe will make it difficult to simulate close combat and COE conditions. Achieving realism and providing training feedback will still be largely a function of expert trainers, and exercise execution will require an adequate number of observer/controllers and role players. For this same reason, simulation technologies are also not likely to increase the quantity of this type of training.

Virtual Simulations. Technology for individual, operator, and maintainer trainers will likely improve considerably and thus has great potential to enhance this type of training (assuming that adequate funding is provided).[2] The same will likely be true of crew trainers, but the potential of squad trainers is likely limited.[3] With regard to multi-echelon collective training, we see few improvements in the close combat tactical trainer (CCTT) capabilities relative to our metrics in

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1 One Semi-Automated Force (OneSAF) and Warfighter's Simulation (WARSIM).

2 The potential will be more limited for individual skills where replication of movement or similar physical activity is needed for positive training transfer.

3 EST (Engagement Skills Trainer) has reportedly proven to be a valuable training tool for squads in the past, but proposed enhancements, to include greater movement and other needed physical realism aspects, have not yet been sufficiently demonstrated to estimate benefits or costs.

the 2016 timeframe, given what we judge to be their limitations in simulating dismounted close combat and other COE conditions.[4]

Simulation-Based Trainers of Leader Tactical Skills. We see great but unproven potential for "serious games" types of leader trainers to improve the quantity of this type of training, especially for small-unit direct fire skills. These trainers for leader skills will grow in both complexity and breadth of application, but the potential for improving training quality and adaptability will be limited by the same factors discussed for constructive simulations. The value of these leader skills trainers has to be closely monitored and assessed.

LVC Training Integration and Tools. The Army's efforts to allow its training simulations to be linked together will provide some important training quality improvements in the timeframe of this analysis. The ability for constructive simulations to stimulate operational hardware[5] (a part of the integration effort) is important for maintaining the relevance of constructive-supported training and allows a means for providing greater realism to live training. But there will likely be fewer gains in the areas of quantity and adaptability in the 2016 timeframe.

With regard to "integrated tools," we see only small improvements to support the design, development, execution, and conduct of after action reviews (AARs) of training events that have integrated some aspects of LVC simulations. There will be training development resource issues surrounding the design of such complex tools.

Embedded Training. In determining our ratings for embedded training, we considered only the benefit and potential of *embedding* the capability itself; however, the quality and adaptability benefits of embedding a training capability can be no greater than the benefit of that capability itself. We found that embedded training will increase some, but not all, types of training. The major increase will be for individual and crew-level training.

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4 Indeed, the usage and benefit of this type of trainer could potentially decrease, given these limitations and the costs of upgrading the tank/infantry fighting vehicle simulators (to include upgraded battle command systems) or to replace them with FCS simulators.

5 "Stimulation" increases training value because the results of constructive simulations can be transmitted to, and followed on, organic equipment, such as the Army Battle Command Systems (ABCS) and other C4ISR systems.

Direct Support to Home Station Training. The enhancements proposed under these initiatives will provide some improvements across the areas of quality, quantity, and adaptability. Increased training manpower can potentially help units address the constraint of leader time to plan, prepare, and execute training events.

Lifecycle Manning. To the degree that positional stability is achieved, this enhancement could significantly reduce the amount of time needed to retrain unit-specific individual and collective skills and thus could lead to indirect but nonetheless important improvement in all three metric areas, especially quantity.

Institutional Training Initiatives. While all these initiatives offer likely quantity improvements, training development resource constraints are likely to limit the benefit of these initiatives because it will be difficult to develop and adapt new content. The exception could be the Battle Command Knowledge System, which, given its collaboration concept, could result in better sharing of lessons learned across the Army.

TRADOC Collective Training Products. Training development resource constraints and limited use of mission training plans (MTPs), combined arms training strategies (CATS), and training support products are likely to limit the benefit of these products.

TRADOC Execution of FCS BCT Fielding. This enhancement could provide benefits across all areas and support spiral development of training methods and products. However, these benefits are not yet programmed, and do not cover training needs beyond the initial fielding period.

Integrated Assessment of Enhancements

Our integrated assessment of enhancements leads to the following conclusions:

- In the face of challenging operational requirements, the planned enhancements as a whole provide important improvements for the training system across a wide spectrum. Further, while the amount varies greatly, all enhancements provide some potential benefit. Of particular note is the degree to which the enhancements focus on technology with large potential payoffs in the long term.

- At the same time, we found no "silver bullet" among the enhancements that would revolutionize training strategies for BCTs within the 2016 timeframe. Indeed, the study concluded that live training will remain the cornerstone of FCS-equipped BCT training programs, even though there is limited potential for increasing the amount of this type of training. This conclusion implies that live training enhancements (such as CTC modernization, home station improvements, and an exportable training capability [ETC]) remain critical and deserve continued emphasis.
- Despite continuing improvements to the training system and adaptations made by unit leaders and trainers, we find that, in the 2016 timeframe, the training capability achieved under currently planned enhancements is likely to remain substantially less than that needed to fully meet future training requirements, especially those generated by the COE. This gap in achievements relative to requirements reflects both how difficult new training requirements are and how high the prior standard was.
- We also conclude that some further shaping and balancing of enhancements could likely improve overall benefits and reduce the gap prior to 2016. The idea that further shaping might improve benefits stems from the following observations:
  - The area of leader training exercises used to train battle command represents the Army's best chance for significant near-term improvement in the training strategy within the 2016 timeframe. Pursuit of this goal could potentially lead to significant improvements not only in training quality, but also in the quantity of events and the adaptability of the training system. However, a greater emphasis on training manpower support relative to training technologies is likely needed to produce a large improvement in overall benefits. More generally, we found a tendency to overestimate what training technologies could accomplish, especially relative to less technological and more traditional means of adding support.

- We found what appeared to be some imbalances in what training enhancements were trying to accomplish. For example, we noted that while many enhancements appeared to be geared toward improving the quality of training, fewer seemed aimed at increasing the quantity of training or producing greater training event adaptability. Moreover, much of this imbalance seemed to derive from an inadequate consideration of key training system constraints, especially limitations in unit leader time.
- We found the training support system (TSS) process somewhat constrained in terms of the information it has available, its analytic capability, and its ability to cross-level resources (see further discussion in bullet below). We believe that more information and better capabilities would have changed its ultimate decisions.

• Successful evolution of the TSS process to identify and defend the most important enablers will be key to the Army's success in making effective use of training dollars. The process the Army currently uses to select, fund, and prioritize training enhancements would benefit from more feedback from units on their current training programs and constraints, and a greater evaluative capability (including effective training metrics) to assess relative costs and benefits across enhancement categories. More mechanisms might also be needed to effect changes in investment strategies once imbalances are discovered.

Recommendations for Effecting Critical Training System Improvements

Despite the challenges faced by the Army's training community, we see possibilities for significant gains in the present environment. To achieve these gains, UAMBL (and the Army) should consider several initiatives.

More Closely Monitor and Manage the Program to Support Training Strategies for BCTs Equipped with FCS Technologies

Certain actions will increase the likelihood of achieving critical training system improvements in the 2016 timeframe. Our recommendations include implementing metrics for the training Key Performance Parameters (KPPs) aimed at quality, quantity, and adaptability improvements in training; and working more closely to monitor existing Key Complementary Programs (KCPs) for the FCS. Two new KCPs should be added: the Battle Command Training Center (BCTC) and U.S. Army Training and Doctrine Command (TRADOC) ability to produce training content.

In addition, the Army should work to obtain or protect critical resources needed to support training enhancements. These resources would include embedded operator and crew trainers and tutorials, training manpower support resources, new operator/maintainer training, and other resources needed to support training deriving from Army modernization, including the spiral-outs.

Continue to Shape Enhancements Within Available Resources

Given the expected gap we identified between training requirements and training system improvements, the key challenge for the Army is to select and effectively develop enhancements that provide the most benefit given the likelihood of considerably constrained training resources. To increase the benefits of the enhancements as a whole, we recommend the Army undertake new spiral development processes to implement TSS initiatives and to effectively evolve training capabilities. Spiral development includes continual observation, assessment, and analysis. If aggressively pursued, spiral development can produce significant benefits from promising training methods and products even when large uncertainties exist.

Greater customer input and increased analytic capability would facilitate a more formalized spiral development process. The process would start with an acquisition and evaluation roadmap associated with each training enhancement designed to provide a basis for recommending updates and changes to programs as they develop. The roadmap would include an evaluation of enhancements during the development phase, as well as longitudinal studies providing feedback from the field on their ongoing impact in later phases. Greater analytic capability would include evolving improved metrics to develop TSS priorities. The metrics would include (1) metrics related to the effect of the enhancements on the quality, quantity, and adaptability of training, (2) cost metrics that allow a more complete identification of the full costs of given capabilities, and (3) field performance metrics that measure the effect of the enhancement and training on actual unit performance.

As an initial step, we recommend a spiral development process to evolve training capabilities in the area of battle command training. While this improved capability would be supported by constructive simulations, the key to the proposal is to increase and better organize training support manpower to take full advantage of the constructive technologies.

Other investigations might also help to better balance training enhancements. For example, training enhancements currently emphasize new technologies with large potential payoffs in the longer term. The Army might balance this emphasis by increasing its focus on potentially high-benefit enhancements to training aids, devices, simulators, and simulations (TADSS) that best meet COE needs but also carry lower risk, involve shorter timelines, and require more modest investments.

Wider Implications

Need for Integrated Funding Strategy

There appear to be structural impediments within the current programming and budgeting process that impede identification of all the relevant resources needed to achieve an integrated and balanced training strategy. Visibility of the costs and benefits of training initiatives and integration of investments across all the initiatives will be especially important in the future. As a first order of business, the Army should strive to consolidate and provide wider visibility of financial information across the training enhancement categories described in this report. Forming "capability modules" in the financial process to correspond to the enhancements identified in this report would allow integration of the total training program across the Program Evaluation Groups (PEGs) and allow the balancing of capabilities across programs.

Trading Off Operational Capability with Training Capability

Our suggestions for improvement also imply the need for increased resources to enable a more expansive training strategy. Without adequate resources for training, the Army is likely to have operational units with advanced technological capabilities and operational concepts that cannot be utilized to their full potential because the units are not fully trained. The training resource strategy should also be integrated with the FCS-equipped BCT program and Army Transformation as a whole to get the right balance of resources between operational capacity and training.

Acknowledgments

Given the magnitude of technical, operational, and organizational changes currently under way in the Army, any study that aims to make a comprehensive examination of future Army unit training strategies must investigate a wide array of programs and initiatives. This study benefited from the support and assistance of many people in the Army and at RAND.

In particular, we want to thank our sponsor, BG Albert Bryant, Jr., at UAMBL, and those on his staff who provided us with valuable input and counsel as we developed the study. We would especially like to acknowledge the assistance and guidance we received from Garry Kendrick, Jim Berg, Kevin Garvey, and Andy Dean in the UAMBL, as well as Bob White of the FCS Program's Integrated Product Team. Dr. Bob Bauer at Fort Knox also provided valuable feedback for early briefings. We also want to note the valuable assistance we received from the PEO STRI staff, especially from Carlton Brown for providing coordination, and Thomas Kelso, LTC Perry Smith, and Cindy Harrison. In addition, we would like to acknowledge the support of Jon Berlin and Timothy Kenny at HQDA G-3, especially with regard to the funding issues involved in training enhancements.

The staff at the National Simulation Center at Fort Leavenworth and the Army Training Support Center at Fort Eustis provided valuable insights and reviews as well as access to key documents. In particular, we would like to thank Thomas Foster, Frank Polster, Michele Hirsch, Terry Faber, Michael Moretti, Wayne Koenig, John "Buck" Mandeville, and Randy Jackson at the Army Training Support Center and Kevin Burke, Daniel Wakeman, Mike Black, and Michael Collins at the National Simulation Center.

We also want to thank the members of the Brigade Command and Battle Staff Training program at Fort Leavenworth for helping us understand the challenges of conducting constructive simulation-supported exercises. We would also like to acknowledge the efforts of Lieutenant Colonel Brian Weking and Michael Boucher in arranging our visits and providing their own insights.

We are also indebted to Nate Goodwin, Russ Hummel, and Brigadier General (RET) Dale Nelson at U.S. Army Forces Command, all of whom provided timely information on the rapidly evolving training programs being implemented to support the Army's Force Generation strategy. We also acknowledge Colonel Gary Brown, Lieutenant Colonel Rich Totleben, Jay Farwell, and Jim Cope at Fort Leavenworth, CTC Directorate, for their assistance in furthering our understanding of the changes being designed for training at the Army's Combat Training Centers. In addition, we would like to thank Colonel Henry Kievaar and Lieutenant Colonel David Hill of the 4th Infantry Division, Major David Fivecoat and Duce Correa of the 3rd Infantry Division, and John Diem, Georgie McAteer, and Major Michael Saluto of III Corps for providing input on the training challenges and training needs of today's operational units.

We also want to thank many individuals who provided input concerning future directions of simulation technologies, artificial intelligence, and the computer game industry. These include LTC Favio Lopez, HQDA G-3; Thomas Foster at the U.S. Army Infantry Center; Dr. Richard Sottler, Sottler-Henke, Inc.; Dr. Michael Van Lent, Institute for Creative Technology, USC; Jim Korris, Institute for Creative Technology, USC; Dr. Richard Clark, USC; Marc Prensky, CEO of Games2Train.com; Dr. Kenneth Koedinger and Dr. John Anderson at Carnegie Mellon University; Miriam Bishay at Vivendi Universal Games; Jeannie Novak, CEO of Indispace, Inc.; and William Murray of Teknowledge, Inc.

This work also benefited from the previous research and input of many RAND colleagues. We especially want to acknowledge Bryan Hallmark, Tom Lippiatt, Randall Steeb, David Oaks, Russell Glenn, Bradley Wilson, Morgan Kisselburg, Arindam Dutta, and Bruce Newsome.

We have benefited greatly from assistance provided by all these individuals. Errors of fact or interpretation, of course, remain the authors' responsibility.

List of Acronyms

AAR	After Action Review
ABCS	Army Battlefield Command System
AC	Active Component
ACR	Advanced Concepts Research
ACTF	Army Constructive Training Federation
AI	Artificial Intelligence
AMT	Army Modernization Training
AO	Area of Operation
AOT	Assignment Oriented Training
ARFORGEN	Army Force Generation
ARI	Army Research Institute
ARNG	Army National Guard
ARTEP	Army Training and Evaluation Program
ARV	Armed Robotic Vehicle
ATIA	Army Training Information Architecture
ATIA-M	ATIA-Migrated
ATSC	Army Training Support Center
AVCATT	Aviation Combined Arms Tactical Trainer
BBS	Brigade/Battalion Battle Simulation
BCBST	Battle Command and Battle Staff Training

BCKS	Battle Command Knowledge System
BCT	Brigade Combat Team
BCTC	Battle Command Training Center
BCTP	Battle Command Training Program
BES	Battlefield Effects Simulator
BFV	Bradley Fighting Vehicle
BLOS	Beyond-Line-of-Sight
BLUFOR	Blue Forces (i.e., the organization being trained in a training exercise)
Bn	Battalion
BOS	Battlefield Operating System
BSC	Battle Simulation Center
C2	Command and Control
C4	Command, Control, Communications, and Computers
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CA	Combined Arms
CAB	Combined Arms Battalion
CALFEX	Combined Arms Live-Fire Exercise
CALL	Center for Army Lessons Learned
CAS	Close Air Support
CATS	Combined Arms Training Strategy
CATT	Combined Arms Tactical Trainer
CBS	Corps Battle Simulation
CCTT	Close Combat Tactical Trainer
CERTEX	Certification Exercise
CFX	Command Field Exercise

CMTC	Combat Maneuver Training Center
Co	Company
COE	Contemporary Operating Environment
COFT	Conduct of Fire Trainer
COP	Community of Practice
CP	Career Program
CPX	Command Post Exercise
CS	Combat Support
CSS	Combat Service Support
CSSTSS	Combat Service Support Training Simulation System
CTC	Combat Training Center
CTIA	Common Training Instrumentation Architecture
DA	Department of the Army
DBST	Digital Battle Staff Sustainment Trainer
DET	Displaced Equipment Training
DIS	Distributed Interactive Simulation
DL	Distributed Learning
DMSO	Defense Modeling and Simulation Office
DoD	Department of Defense
DRTS	Digital Range Training Systems
EST	Engagement Skills Trainer
ET	Embedded Training
ETC	Exportable Training Capability
FA	Functional Area
FCS	Future Combat Systems
FCX	Fire Coordination Exercise
FIST	Fire Support Team

FM	Field Manual
FOF	Force on Force
Force XXI	Tank Battalion
FORSCOM	Forces Command
FOT	Force on Target
FSB	Forward Support Battalion
FSO	Fire Support Officer
FTX	Field Training Exercise
HITS	Home Station Instrumentation System
HLA	High Level Architecture
ICD	Initial Capabilities Document
ICV	Infantry Combat Vehicles
ID	Infantry Division
IED	Improvised Explosive Device
IMI	Interactive Multimedia Instruction
IMS	Intelligent Munitions System
IMT	Initial Military Training
IMTS	Integrated MOUT Training System
ISR	Intelligence, Surveillance, and Reconnaissance
JANUS	An Army constructive simulation
JAVA	A programming language
JAWS	Joint Asymmetric Warfare Simulation
JCATS	Joint Conflict and Tactical Simulation
JIIM	Joint, Interagency, Intergovernmental, and Multinational (referring to an operational environment)
JIT	Just-in-Time
JLCCTC	Joint Land Component Constructive Training Capability

JRAM	Joint Regional Analysis Model
JRTC	Joint Readiness Training Center
JSIMS	Joint Simulation System
KPP	Key Performance Parameter
LFX	Live-Fire Exercises
LOS	Line of Sight
LT2	Live Training Transformation
LTP	Leader Training Program
LTSTS	Leader Tactical Skills Training Simulation
LTX	Lane Training Exercise
LVC	Live-Virtual-Constructive
LVC-IA	Live-Virtual-Constructive Integrated Architecture
MAPEX	Map Exercise
MCO	Major Combat Operation
MCS	Mounted Combat System
MDEP	Management Decision Evaluation Package
METL	Mission Essential Task List
METT-TC	Mission, Enemy, Terrain and Weather, Troops and Support Available, Time Available, and Civil Considerations (referring to an operational environment)
MI	Military Intelligence
MILES	Multiple Integrated Laser Engagement System
MOS	Military Occupational Specialty
MOUT	Military Operations on Urban Terrain
MP	Military Police
MRX	Mission Rehearsal Exercise
MTP	Mission Training Plan
MULE	Multifunctional Utility/Logistics and Equipment

NBC	Nuclear, Biological, Chemical
NCO	Noncommissioned Officer
NCOES	NCO Education System
NET	New Equipment Training
NETT	New Equipment Training Team
NGATS	New Generation Army Target System
NGO	Nongovernmental Organization
NLOS-C	Non-Line-of-Sight Cannon
NLOS-LS	Non-Line-of-Sight Launch System
NLOS-M	Non-Line-of-Sight Mortar
NTC	National Training Center
OC	Observer/Controller
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
OIS	Objective Instrumentation System
OneSAF	One Semi-Automated Force
O&O	Operational and Organizational Plan
OOS	OneSAF Objective System
OPACE	Operational Pace
OPFOR	Opposing Force
OPORD	Operation Order
OPTEMPO	Operational Tempo
ORD	Operational Requirements Document
PEO STRI	Program Executive Office for Simulations, Training, and Instrumentation
PGSS	Precision Gunnery Simulations System
Plt	Platoon
PM	Program Manager

PME	Professional Military Education
POI	Program of Instruction
POM	Program Objective Memorandum
PSYOP	Psychological Operations
PUB-SUB	Publish and Subscribe
QTB	Quarterly Training Briefs
RC	Reserve Component
R&D	Research and Development
R&S	Reconnaissance and Surveillance
RDA	Research Development and Acquisition
ROE	Rules of Engagement
ROI	Rules of Interaction
RSTA	Reconnaissance, Surveillance, and Target Acquisition
SaaS	Soldier as a System
SAF	Semi-Automated Force
SBCT	Stryker Brigade Combat Team
SCORM	Sharable Content Object Reference Model
SD	Self-Development
SE	Synthetic Environment
SIM	Simulation
SIMNET	Simulation Network (Model)
SME	Subject Matter Expert
SOF	Special Operations Forces
Soldier-CATT	Soldier Combined Arms Tactical Trainer
SOP	Standard Operating Procedures
SoS	System of Systems

SOSCOE	System-of-Systems Common Operating Environment
SOSO	Stability Operations and Support Operations
STIM	Stimulation
STRAP	System Training Plan
STX	Situational Training Exercises
SUGV	Small Unmanned Ground Vehicle
TACOPS	Tactical Operations Simulation
TACSIM	Tactical Simulation
TADSS	Training Aids, Devices, Simulators, and Simulations
TCCFCS	Training Common Components for FCS
TD	Training Development
TEMO	Training, Exercises and Military Operations
TEO	Training and Evaluation Outline
TESS	Tactical Engagement Simulation System
TF	Task Force
TOC	Tactical Operations Center
TOE	Table of Organization and Equipment
TOW	Tube-Launched Optically Tracked Wire-Guided (Missile)
TRADOC	U.S. Army Training and Doctrine Command
TSP	Training Support Package
TSS	Training Support System
TTPs	Tactics, Techniques, and Procedures
TWGSS	Tank Weapons Gunnery Simulations System
UA	Unit of Action
UAMBL	Unit of Action Maneuver Battle Lab
UAV	Unmanned Aerial Vehicle

UGS	Unattended Ground Sensor
UGV	Unmanned Ground Vehicle
V-TOC	Virtual Tactical Operations Center
WARSIM	Warfighter's Simulation

CHAPTER ONE

Introduction

The Army is adapting its organizations, operational concepts, and systems to meet the needs of the current demanding security environment while also maintaining a focus on the changes needed to transform over the longer term. Ongoing operational challenges include frequent deployment rotations, a more adaptive enemy, an expanded array of missions, and the need to rapidly transition from combat operations to stability operations and support operations (SOSO). In the future, the Army can expect to see increased use of joint and combined arms capabilities at lower echelons, more self-contained and leaner unit designs, and the continuing introduction of new technologies, such as internetted command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) technologies, including robotics.

These changes are placing increased demands on the Army's collective, leader, and soldier training programs now, and the demands can be expected to increase in the future. Future training will need to provide soldiers at all grade and experience levels with sufficient technical expertise to use new systems as well as the skills necessary to achieve mission success in an increasingly complex operating environment. Training will likely need to cover a larger range of skills and be capable of adapting quickly to reclassification training surges, future changes in direction, and the addition of new missions. Training will also need to help units achieve readiness quickly and sustain high levels of readiness over time to meet the pace of deployments. Over the longer term, training systems will also have to assist commanders in implementing tailored "just-in-time" training (e.g., mission rehearsals) for specific deployments and missions. All this must be achieved, moreover, despite constraints on training resources, especially in terms of manpower.

This study seeks to help the Army address these challenges by identifying options for improving the Army's future training strategy for Brigade Combat Teams (BCTs) equipped with Future Combat System (FCS) technologies. The project has two overarching objectives:

- Assess the effectiveness of the current set of planned enhancements to the Army training strategy given the Army's emerging training needs and future training requirements.
- Identify key improvements to training capabilities that the study's sponsor, Unit of Action Maneuver Battle Lab (UAMBL), might champion to increase the effectiveness of the emerging training strategy.

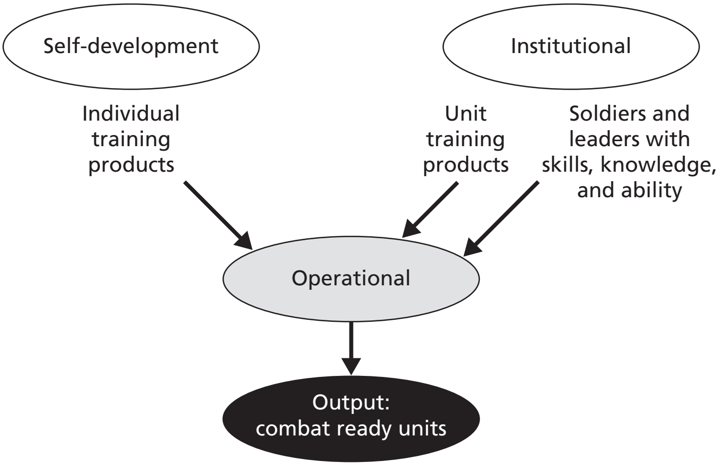
Overview of Army Training Strategy

Current training and education strategies are defined in Army Field Manuals (FM) 7-0 and 7-1 and in Army Regulation 350-1. The overall goal of the training and education system is combat unit readiness. Three categories of training contribute to this goal: individual, collective, and Army Modernization Training (AMT). Individual training refers to soldier and leader training; collective training refers to training of organizations; and AMT refers to systems training (on operation, use, and maintenance) to support the fielding of new or displaced equipment and software systems.

Training in Three Domains

As portrayed in Figure 1.1, all categories of training are conducted in three domains: institutional, operational, and self-development.

Figure 1.1
Army Training Strategies



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Institutional training refers to individual training and education conducted at or by proponent schools. For example, newly enlisted personnel receive Initial Military Training (IMT), which consists of training in basic skills, knowledge, and task proficiency. Newly commissioned officers also receive IMT as part of their development into competent, confident unit leaders.

Later in their careers, Army leaders receive additional institutional training in the form of technical, tactical, and leader training provided as part of Professional Military Education (PME) courses for officers, noncommissioned officers (NCOs), and warrant officers (WOs). Institutions also conduct "functional" courses, which are designed to enhance soldiers' skills for specialty positions such as battalion motor officer. Overall, institutional courses provide a significant amount of training at the individual level, but do not provide all or even most of the training in skills and tasks needed for unit collective performance.

Soldiers and leaders therefore also participate in operational training, which includes both individual and collective training conducted in the unit. Operational training is planned and executed by the unit chain of command with institutional support. Individual training in the unit focuses on soldiers' and leaders' individual skills critical to unit success. Collective training programs develop unit proficiency at all levels, from system/crew/team through BCT. The unit chain of command conducts collective and individual training as integrated activities; that is, individual tasks are trained or enhanced by application during collective exercises.

U.S. Army Training and Doctrine Command (TRADOC) schools support unit training by providing commanders and leaders with training support materials and products, including Army training and evaluation programs (ARTEPs), FMs, combined arms training strategies (CATS), and training support products. Schools also develop the requirements for training aids, devices, simulators, and simulations (TADSS), including ranges and targetry. TRADOC also provides reachback and mobile training team support within capabilities, and it supports unit participation in the Combat Training Center (CTC) program. CTC rotations provide unit commanders with the opportunity to train collective tasks realistically to a level not possible at home stations.

The materiel community also supports unit training by providing TADSS and modernization training on new equipment and systems. New Equipment Training (NET) or Displaced Equipment Training (DET) teams conduct operator and maintainer training, and Doctrine and Tactics Training (DTT) teams teach tactical employment of the new system.

Self-development training refers to individual professional development in preparation to fight and win wars. Self-development is a continuous activity, which is designed to supplement training in the institutional and operational domains. Typically, an individual follows an informal program, which is planned and overseen by his or her supervisor. TRADOC schools support self-development training by supplying training support materials and products.

At the time of this writing, many proposals and concepts to change the Army's training programs are being considered. Some directions are more clear than others, such as increases in availability of proponent school instruction via distributed learning methods and use of simulations in unit training programs. However, the specifics and effects of these and other changes are a matter of debate, and the proposals themselves are undergoing constant change. What is clear is that there will be significant change in the future.

While this study covers training within all three domains, its primary focus is on the operational domain.

Army Force Generation (ARFORGEN) Readiness and Training Strategy

The Army is currently initiating major initiatives in the way it mans and trains operational units, with the overall goal of improving its capability to provide ready units to meet emerging global force requirements. The specifics of this strategy are rapidly evolving, but will have major effects on the way future training is implemented.

Approach Used in This Study

In the study, we first identified increases and changes in future training requirements. With this information as a foundation, we examined the Army's current training capabilities, including the frequency of and performance on recent leader and collective training exercises. We then assessed an array of enhancements that have been identified for supporting the Army training strategy and identified gaps between requirements and likely achievements. We analyzed ways to address the gaps found and to attain a more cost-effective balance among the enhancements. In this context, we reviewed the existing process the Army uses to balance investments in training support. Finally, we recommend related actions that thus should be given priority in future Army budgeting cycles.

The major data sources used in this study are shown in Table 1.1.

Table 1.1
Data Sources Used in This Study

Current Force	Future Force
• Interviews and focus groups – Evolving Army units: Stryker Brigade Combat Team (SBCT), 4th ID, 3rd ID – Training technology developers • Examination of unit training data (3rd and 4th ID) • Training and operational doctrine and other publications • Past RAND research – NTC Unit Training Proficiency (1998–present) – Unit Training Strategies (2001–2002) – Institutional Training Study (2004)	• FCS Unit of Action (UA) plans and related Army training documents – Operational and Organizational Plan (O&O), System Training Plan (STRAP), Army Digital Training Strategy (ADTS), ALDTP, ATS • Interviews with Army and private-sector organizations involved with new training enhancements • Interviews with technology trainers and leaders • Discussions with Department of the Army (DA) personnel responsible for training policies, priorities, and budgets • Current training developments via web, face-to-face, Training Integrated Product Team (IPT), Program Executive Office for Simulations, Training, and Instrumentation (PEO-STRI)

Organization of This Report

The remainder of this report is divided into eleven chapters:

- Chapter Two identifies increases and changes in future Army training requirements.
- Chapter Three establishes a baseline for improvement by offering a general assessment of current Army training performance.
- Chapter Four identifies and describes the method used to assess planned training system enhancements.
- Chapter Five provides an assessment of planned live training enhancements.
- Chapter Six provides an assessment of planned enhancements for constructive simulations.

- Chapter Seven provides an assessment of planned enhancements for virtual simulations.
- Chapter Eight provides an assessment of planned enhancements for simulation-based leader tactical skills training. These capacities are those based on "serious games" technologies.
- Chapter Nine provides an assessment of integrating enhancements, that is, Live-Virtual-Constructive Integrated Architecture (LVC-IA), LVC training tools, Embedded Training (ET), and manpower supporting training at home stations.
- Chapter Ten provides an assessment of other planned enhancements, i.e., lifecycle manning, institutional training initiatives, TRADOC collective training support products, and TRADOC execution of initial fielding for FCS-equipped BCTs.
- Chapter Eleven provides an integrated assessment of the twelve training enhancements.
- Chapter Twelve offers our recommendations.
- Appendices A, B, and C offer additional technical information in support of the main chapters, including an approach to how the Army might improve training in battle command skills.

CHAPTER TWO

Change in Army Training Requirements

This chapter describes the changes in Army training requirements that will affect BCTs equipped with FCS systems. Training requirements are changing, and are likely to increase, due to expanding operational requirements, new operational concepts, new organizational designs, and new operational technology.[1] Below we describe each of these causes, and then discuss their training implications. In selected areas we go into more detail to highlight some of the more challenging new requirements. From the training demands, we derive specific categories of need for training improvement.

Sources of Changed Training Requirements

Expanding Operational Requirements

Heavy maneuver units can no longer focus almost exclusively on training for major conflict. The current "long war" requirements to combat terrorism are expected to continue well into the advent of FCS BCT fielding, and this will likely continue to include a large proportion of the force deployed in ongoing operations. Units not on, or pre-

1 The nature of the changing requirements laid out in this chapter is based on a review of several key documents. Included are TRADOC PAM 525-3-90*, The United States Army Future Force Operational and Organizational Plan, Maneuver Unit of Action, Change 3*, dated September 2004; *Future Combat Systems System Development and Demonstration Plan Phase, Spiral Out Strategy Paper,* PEO, Ground Combat Systems, dated January 2005; *Army Comprehensive Guide to Modularity*, Headquarters TRADOC, dated October 2004; and *Quadrennial Defense Review Report*, Department of Defense, dated February 2006.

paring for, operational deployments must be prepared to deploy to a wide range of operational missions and environments. Future operations are expected to include some mission combination of combat, support, and stability. Even for major conflict operations, BCTs must be prepared for an enemy who fights asymmetrically, i.e., the enemy can be expected to use tactics to negate our technological and tactical advantages, including irregular hit-and-run, concealment of combatant forces inside of civilian populations, and other terrorist methods. Preparation for full-spectrum operations and the ability to make rapid adjustment to changing operational conditions are and will remain a major challenge for the training system.

New Operational Concepts

The concept of highly mobile, technologically advanced, FCS-equipped brigade combined arms teams will be the centerpiece of the transforming Army.

These combat elements—made up of combined arms maneuver battalions and their supporting units—are envisioned to have the capability to conduct joint operational maneuver from strategic distances, creating havoc for U.S. adversaries by arriving at multiple points of entry.

This force will (1) operate as part of a joint, combined, and/or interagency team, (2) be capable of conducting rapid and decisive offensive and defensive combat operations, and also stability and support operations, and (3) be able to transition among any of these missions without a loss of momentum. It must simultaneously be lethal and survivable; responsive and deployable for rapid mission tailoring and the projection required for crisis response; versatile and agile for success across the full spectrum of operations; and sustainable for extended regional engagement and sustained land combat. This force operates in greatly enlarged areas of operations; will network fires and maneuver in direct combat; will deliver direct and indirect fires; perform intelligence, surveillance, and reconnaissance functions; and will transport soldiers and material as the means to tactical success. Lethality will be produced through precise, networked, near-instantaneous "sensor-to-shooter" data, with built-in capabilities for line-of-sight, beyond-line-of-sight, and non-line-of-sight engagements.[2]

New Organizational Designs

Army combat organizations are transitioning into modularized BCTs, and then will transition into FCS-equipped BCTs, which will also be of modular design.[3] Modularity refers to the reorganization of combat divisions into smaller modular BCTs, thus increasing the number of maneuver BCTs. Modular BCTs are designed to be more self-contained, that is, they will have divisional "slices" included in their unit structure—hence the term "modular." For example, military intelligence (MI), signal, engineer, and military police (MP) units will be organic to the modular BCT, and many C2 and integration functions that were formerly performed at divisional level have been shifted to the BCT level.

The FCS-equipped BCT formation is to consist of three FCS-equipped Combined Arms Battalions (CABs), a Non-Line-of-Sight (NLOS) Cannon Battalion, a Reconnaissance, Surveillance, and Target Acquisition (RSTA) Squadron, a Forward Support Battalion (FSB), a Brigade Intelligence and Communications Company (BICC), and a Headquarters Company.

The capabilities of advanced technology are leveraged to reduce manpower requirements, and personnel strength is expected to be 15 to 20 percent lower than the strength of the modular heavy BCTs. For example, advanced ISR capabilities are assumed to eliminate the need for organic engineer units and lead to greater system reliability, reduced fuel requirements, and greater synchronization capabilities to allow a great reduction in CSS manpower.

The FCS-equipped BCT's relatively low personnel strength will require it to make maximum use of the state-of-the-art C4ISR sys-

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2 TRADOC PAM 525-3-90.

3 The organizational design of the FCS-equipped BCT outlined in TRADOC PAM 525-3-90 and that of the current modular BCT differ in some major aspects. However, it is reasonable to assume that the lessons learned from modular BCTs will result in changes to the FCS-equipped BCT's organizational design and concepts. Therefore, in this section we emphasize the common elements.

tems that, in theory, give it unprecedented operational understanding, maneuverability, sustainability, survivability, and lethality.

New Operational Technology

At the center of this transformation, and enabling the future force to bridge across the full spectrum of mounted and dismounted warfare, is information technology, specifically, the force's "internetted" C4ISR technologies, including robotics. These enable a joint (across all military services), networked (connected via advanced communications) "system of systems (SoS)." The SoS refers to 18 direct operational systems plus the network plus the soldier.

The FCS network is the centerpiece of operational technology and will allow the FCS environment to operate as a cohesive SoS. The network rests upon four essential building blocks: SoS Common Operating Environment (SOSCOE); Battle Command (BC) Software; Communications and Computers (CC); and ISR systems. The FCS direct systems will be made up of both manned and unmanned ground platforms, a range of fire systems (including both direct and indirect fire capabilities), unmanned aerial and ground vehicles (UAVs and UGVs), and distributed sensors.

FCS technologies are currently planned to be fielded to existing BCTs in a series of four "spiral-outs." The first spiral-out to operational BCTs is planned for the 2010 timeframe, and the three others follow at two-year increments. The first spiral-out is currently planned to include the NLOS cannon ("NLOS-C"), the NLOS-LS (unmanned), unattended ground sensors ("UGSs"), and two classes of unmanned aerial vehicles (Class I and IV "UAVs"). In addition, continuous upgrades of network technology will be common to all four spiral-outs.[4]

Figure 2.1 provides an image of the FCS systems, while Table 2.1 depicts these 18 direct systems, the spiral-out package to which each is currently assigned, and other information regarding the systems.

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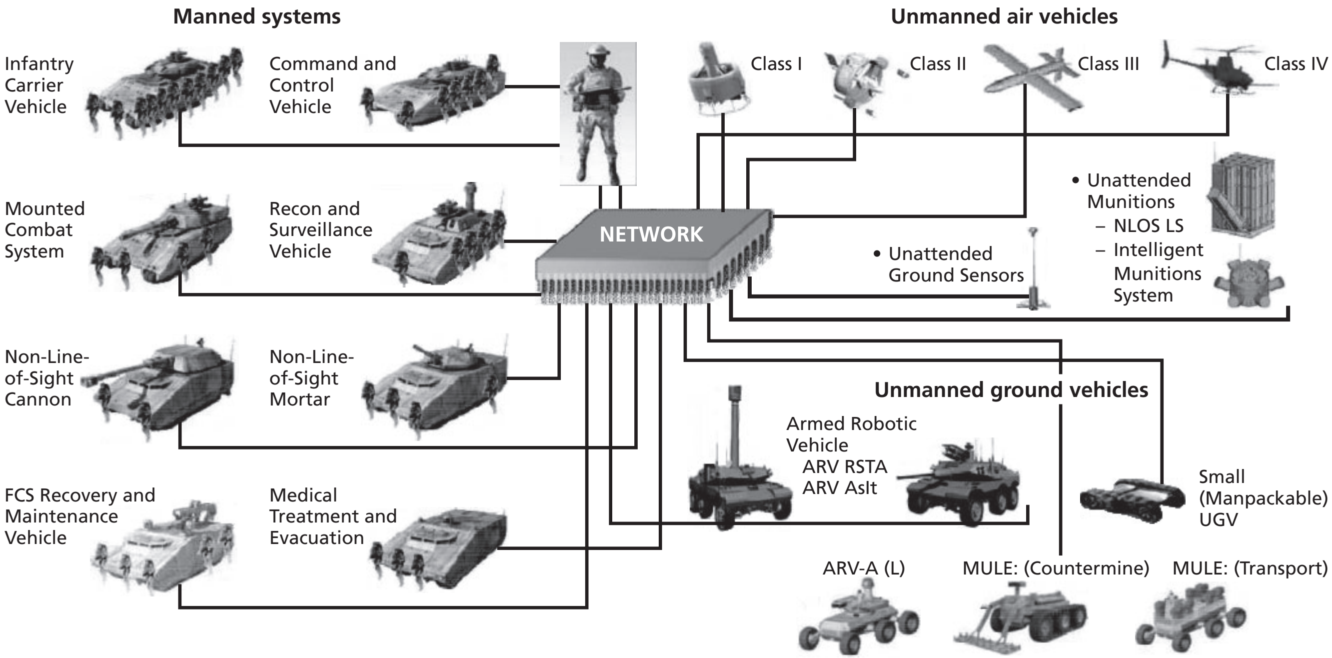
[4] *Future Combat Systems—Systems Development and Demonstration Phase Spiral Out Strategy Paper* (Draft Document), January 10, 2005.

Figure 2.1
Future Combat Systems



SOURCE: http://www.globalsecurity.org/military/systems/ground/fcs.htm.
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Table 2.1
FCS Direct Systems

System	Manned	Unmanned	Spiral Out	Key Attributes
1. Ground Sensors		x	1	Sensors will provide "content" for network centric-shared information.
2. Smart Munitions		x	1	Intelligent mines and demolitions, lethal/nonlethal, via FCS-equipped BCT's C4ISR network.
3. NLOS-LS		x	1	Non-line-of-sight launch system. Two missiles and a launch system integrated with the network. NLOS-LS will be platform independent.
4. NLOS-C	x		2	Non-line-of-sight cannon. A combat vehicle with a 120–155mm cannon that has NLOS capability. Incorporates smart submunitions; fire-and-forget technology.
5. NLOS-M	x		2	Non-line-of-sight-mortar. A combat vehicle with a 120mm mortar that has NLOS capability.
6. UAV CL I		x	2	Unmanned aerial vehicle, Class I. Small payloads; man-packed; Plt-sized RSTA operations: for MOUT.
7. UAV CL II		x	3	Unmanned aerial vehicle, Class II. Vehicle-mounted, for infantry companies and MCS platoons beyond 2 intervisibility lines.
8. UAV CL III		x	3	Unmanned aerial vehicle, Class III. Target acquisition for NLOS battalion precision fires and reconnaissance detection of CAB.
9. UAV CL IV		x	2	Unmanned aerial vehicle, Class IV. Large payloads; long-endurance surveillance/targeting throughout the FCS-equipped BCT area of operations.
10. UGV: Armed Robotic		x	3	Unmanned ground vehicle with armed robotics. Has common chassis with 2 variants; ARV Assault and ARV RSTA. Used to rapidly shape battlespace; provide force protection.
11. UGV: Multi-functional Logistics		x	4	Unmanned ground vehicle, multifunctional logistics. Provides transport of equipment and/or supplies of dismounted maneuver forces.

Table 2.1—continued

System	Manned	Unmanned	Spiral Out	Key Attributes
12. Small UGV		x	4	Small unmanned ground vehicle. Man-packed small robot system—30 lbs—for urban operations and subterranean features, to remotely investigate threat.
13. ICV	x		4	Infantry carrier vehicle. Transports a full 9-man infantry squad with associated gear and 2-man crew.
14. MCS	x		4	Mounted combat system. Combat vehicle with 105–120mm cannon with LOS/BLOS capability.
15. C2 Vehicle	x		4	Command and control vehicle. Provides 4-man workstation, driver, commander, for control of UGVs/UAVs.
16. R&S Vehicle	x		4	Reconnaissance and surveillance vehicle: integrates RSTA suite of 5-meter mast, thermal images (LWIR and MWIR), day/night TV camera, 10 km+ laser range finder, Ka band radar, 360 degrees all elevation azimuth. Provides 2-soldier workstation, driver/commander.
17. Maintenance Vehicle	x		4	General-purpose vehicle with embedded semi-autonomy. The crew consists of a driver and commander.
18. Medical Vehicle	x		4	Vehicle provides evacuation and/or medical treatment. Provides 1 injured station, 1 driver, and 1 commander.

As shown in the table, in addition to the FCS network, the systems include unattended ground sensors (UGS); two unattended munitions—the NLOS launch system (NLOS-LS) and intelligent ("smart") munitions; four classes of unmanned aerial vehicles (UAVs) organic to platoon, company, and battalion and supporting FCS-equipped BCTs; three classes of unmanned ground vehicles (UGVs), armed robotic (with both RSTA and assault variants); multifunctional utility/logistics and equipment ("MULE"); and a small unmanned ground vehicle (SUGV). The FCS SoS will also include the eight manned vehicles at rows 4, 5, and 13 through 18 of Table 2.1. FCS, as the essential building block of the future force, will be the centerpiece of the FCS-equipped BCT, the latter now termed the Army's "future tactical war fighting echelon."

Soldiers in FCS-equipped BCTs will be a part of the "Soldier as a System" (SaaS) requirement, one that encompasses what the soldier wears, carries, and consumes, including unit radios, crew-served weapons, and unit-specific equipment in the execution of tasks and duties. All soldiers' systems will be treated as an integrated SoS. SaaS establishes a baseline for core soldier requirements (e.g., aptitude, skill set), and will establish the foundation for specific or mission-unique Warrior Programs (Land, Mounted, and Air). It will present a fully integrated soldier who provides a balance of tasks, and mission equipment in support of the soldier team, FCS, and the future force.

Army Force Generation Model

The Army Force Generation (ARFORGEN) model is an ongoing effort to improve training and readiness programs to meet challenges generated by modernization and changing operational requirements and operational concepts. ARFORGEN is an approach to synchronizing requirements for deployable forces in a logical, systematic manner. Although specific components of ARFORGEN are still being developed, the objective is to provide regional commanders with enough trained and ready units to meet ongoing operational requirements and to be able to respond to a full range of planned and unplanned contingencies.[5]

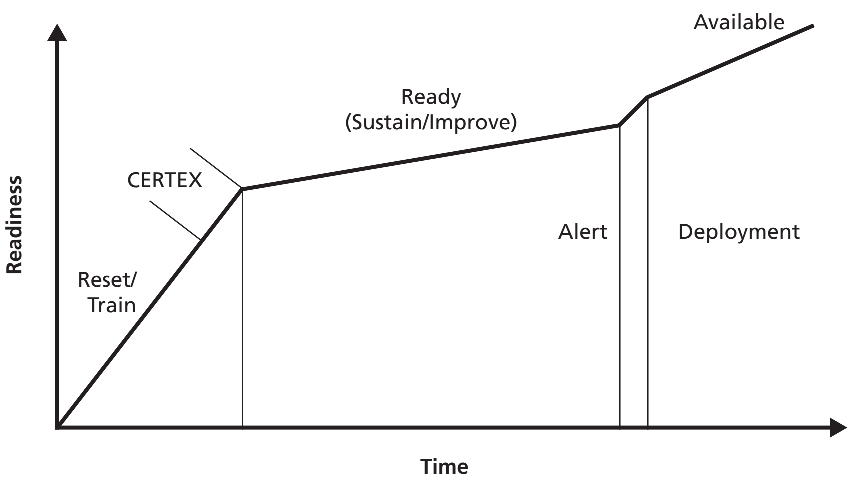
Under ARFORGEN, training concepts change from the former "Band of Excellence" standard, under which all units were expected to maintain relatively high readiness within an allowable "band" of inevitable fluctuations, to a standard in which units are expected to constantly increase readiness within a cycle (hence the upward-sloping lines in the figure below), but which accepts that some units will be in

[5] Army Campaign Plan, Change 3, dated 12 May 2006. The ARFORGEN strategy is currently being developed. This section's content is also based on a review of several FORSCOM briefings and draft concept papers, as well as discussions with FORSCOM training staff members working on the development of this strategy.

a category that is not deployable. Under ARFORGEN, units undergo a structured progression of readiness training as they move through three readiness pools, two of which are deployable. The ARFORGEN cycle (see Figure 2.2) is intended to be three years for active component (AC) units and five or six years for reserve component (RC) units, with AC and RC units each spending one year of their respective cycles in the available pool. The pools are defined as follows:

- **Reset/Train.** Units start this phase upon return from deployment or after one year in the available pool. The goal of reset/train is rapid reconstitution and training to enable units to re-enter the ready pool as soon as possible.
- **Ready.** These units are prepared for operational deployment, if required to meet surge requirements. If deployment is not required, the unit focuses on improving its readiness and training levels.
- **Available**. These units are deployed or are fully prepared for rapid deployment to specific theaters, or are capable of full-spectrum operations to meet unplanned contingencies.

Figure 2.2
ARFORGEN Training and Readiness Cycle



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Movement of BCTs from one pool to the next depends on the successful completion of mandatory events, including an appropriate Combat Training Center (CTC) or equivalent gate event, and a commander's assessment that adequate readiness levels have been achieved. Units report readiness against appropriate levels given their force pool and assigned operational missions.

Training Demands of the New Requirements

This section summarizes increased training demands resulting from operational and organizational changes and modernization. Overall, the changes described above will require Army training to:

- Train new technologies, more complex joint C4ISR (JC4ISR).
- Prepare leaders for more complex tasks and skills, multitasking, adaptation.
- Cover a larger range of skills.
- Adapt to frequent changes in training direction and addition of new missions.
- Help soldiers maintain a higher level of readiness.
- Adjust to constraints on resources, especially military manpower.
- Train for full-spectrum operations.

Following are more particular training implications in several areas.

Training Implications of Changing Operational Requirements

Our review of ongoing BCT training programs shows that evolving operational requirements have caused more changes in BCT training programs than modernization and modularization.[6] The changing operational environment increases the range of tasks and the task conditions that the training system must support, and this wider range of possible missions and conditions increases the difficulty of setting up realistic training, especially at home station. The likelihood that

[6] These are discussed in detail in the next chapter.

future foes will use asymmetric tactics to combat U.S. forces makes use of blue-on-blue[7] techniques less realistic and effective for training. Changed operational requirements also mean that BCTs must be trained to operate across a wide range of conditions, and that military operations on urban terrain (MOUT) and interaction with local populations and joint, interagency, intergovernmental, and multinational (JIIM) partners will be the norm. Creating a realistic training environment, as the experience of any of the CTCs would attest, has become a more complex and time-intensive challenge, and is resource-intensive as well.

A key challenge for FCS BCT training programs will be to improve capacities to meet ongoing operational requirements while maintaining the capability to react to surge operational contingency requirements.[8]

Ongoing operational requirements, such as Operation Iraqi Freedom (OIF), require extensive training programs and will be the training system's priority. Such training will also detract from training resources for FCS BCT specific training, at least to some extent. Moreover, as operations in OIF have shown, adversaries adapt to counter the technical capabilities of modernized forces. Consequently, the FCS BCT's training programs must be equally adaptive.

Preparing for planned and unplanned "surge" contingencies will be in many ways an even more demanding training requirement. Some could require a large number of BCTs.[9] Moreover, the range of missions and conditions will be even greater than for steady-state operations.

These considerations lead to a conclusion that the training system must be able to rapidly adapt. The nature of operational missions and conditions will continue to emerge and change, generating a need for the training system to adjust to support changing training objectives. Future operational requirements can be predicted with limited cer-

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7 Exercises in which each BCT uses its normal organization and tactics.

8 See the section on "Operationalizing the Strategy" in the 2006 *Quadrennial Defense Review* for a more detailed discussion of surge and steady-state requirements.

9 For example, see J. Quinlivan, *Burden of Victory: The Painful Arithmetic of Stability Operations,* RAND Review, Summer 2003.

tainty, and, when they arise, the training system must be able to rapidly adapt to set up effective training programs for follow-on units. The need to adapt also applies to creating a capability to support postdeployment training programs to adjust to changing in-theater METT-TC.[10]

Training Implications of FCS BCT Organizations and Operational Concepts

Organizational changes and operational concepts will add to the requirements of the training system in several ways.

- **Reduction in senior leader oversight of training.** BCTs lack the battalion and separate company training oversight and expertise that was previously provided to engineer, MP, signal, and MI units. For example, intelligence and signal companies are moved from divisional battalions into a single BCT company, but the new organization does not include a lieutenant colonel commander, a major S3, or a command sergeant major, all of whom have played important roles in the past in supporting and supervising intelligence and signal-specific training and mentoring of junior leaders.
- **Decrease in relative availability of training facility resources.** Although ongoing modularity initiatives are expected to increase the number of BCTs by 30 percent, we see no commensurate increase in the number of maneuver ranges, simulation centers, CTC capacities, and other training capabilities. Nor are increases in facilities and capacities being undertaken as a result of the increased requirements likely to be generated by BCTs' greater envisioned operational capabilities and concepts. As a key example, enhanced ISR and effects capabilities generate a need for a greater maneuver area for live training. The area of influence for

[10] METT-TC is mission, enemy, terrain and weather, troops and support available, time available, and civil considerations.

current modular BCTs is up to 60 kilometers in diameter, and for an FCS-equipped BCT, this would increase to 75 kilometers.[11]

- **Need for improved training programs due to full-spectrum operations**. Full-spectrum operations increase the challenge of coordinating training calendars. For example, with austere CSS, and no organic general support aviation or engineer capabilities, augmentation from support, aviation, and maneuver enhancement brigades will be needed for all types of operations, especially for stability and support operations. Similarly, stability and support operations will likely require extensive human intelligence (HUMINT), civil affairs (CA), and psychological operations (PSYOP) augmentation and likewise generate training coordination challenges. In addition, full-spectrum operations add to, and complicate, training requirements. For example, irregular enemy tactics increase the requirement for self-protection throughout the battle area, and the reduced crew sizes (allowed by advanced technologies) will make self-protection difficult. Another major complication will be that many JIIM organizations and noncombatants will be in the FCS BCT's battlespace but will not be equipped with FCS command, control, communications, and computers (C4) capabilities, and this will complicate FCS command and control processes.
- **Increase in command and control training requirements**. The FCS BCT's concepts place great emphasis on leveraging C4 systems to synchronize operational and support capabilities across larger battlespaces, and this creates a greater need to train leaders on complex synchronization skills. In addition, leaders in a BCT will often require a higher training level for their grade. The BCT takes on tasks that were previously performed at division level, yet leader and staff grade, as well as experience levels, remain basically those of a brigade-level organization. This requirement goes to lower echelons. At maneuver platoon level, leaders are expected not only to fight direct fire battles, but to use UAV and

[11] The area of influence is a geographical area wherein a commander is directly influencing operations by maneuver or fire support under the commander's command and control.

fires to simultaneously engage the enemy "over the hill," again with current-grade-level leaders and soldiers.

Training Implications of Modernization

In general, FCS operational technologies will significantly change the nature of soldiers' and leaders' tasks. In some cases, technology could make training easier for particular skills (e.g., improved sights will decrease the difficulty of target identification, acquisition, and engagement, and computer support could potentially automate these tasks on some systems). But in other areas, technology will increase training demands. For example, full leveraging of C4ISR technologies will require training in complex analysis, planning, real-time decisionmaking, and rapid adaptation. In addition, because neither the number of soldiers in a brigade nor the aptitude of those soldiers is expected to increase in the future, the same soldiers will need to be better trained in order to learn more skills in general and more complex skills at all levels.

The technical aspects of transforming combat units have also affected ongoing training programs. Modernization for modular BCT refers to efforts to enhance the capabilities of C4ISR and precision fire systems. To modernize BCTs, the Army is planning to phase in a range of new equipment, including the Army Battlefield Command System (ABCS) suite of C4 capabilities, unmanned aerial vehicles (UAVs), and sensor systems.

While all these initiatives offer the potential to enhance operational capabilities, they will add to the requirements of the training system for several reasons. In particular, these initiatives will impact training time. For example, as we mentioned previously, it takes time to draw and train on new equipment. These activities will take away from time available for normal individual and collective training. Other impacts include the following:

- Modernization adds to training requirements by increasing the number of systems on which soldiers and leaders must be proficient. For example, unmanned ground vehicles (UGVs), which must be operated by infantry soldiers and used by infantry lead-

ers, would represent an added system on which soldiers and leaders must be trained. Digitization to enhance command and control means that in addition to basic skills required for this function, leaders must be trained both to use the new computer and communications systems that support this function and to use the additional information effectively.
- Sustainment training requirements grow as a result of the increased number of systems. For example, current digital field artillery systems have generally been considered to require monthly sustainment training periods.

Training Impacts of Spiral-Outs

In general, modernization will add to requirements because of the need to train more systems within the same amount of available training time.

The level of this impact will depend on several factors, which are currently somewhat uncertain as to their timing, nature, and effect. First is the scheduling of the spiral-outs. Each FCS technology will spiral out only if initial prototype efforts demonstrate that it provides combat benefit and can be affordably produced; thus, the schedule discussed earlier could change. Second is the difficulty of operating and using the technology, the extent of which will not be fully understood until initial operational testing is complete. A third consideration is the question of which organizations in the BCT will get the new systems. For example, if UGS goes to military intelligence units to replace current sensors and is operated by dedicated soldiers, the impact on training will not be large. However, if these systems are given to infantry companies and platoons and the operators are designated infantry Military Occupational Specialty (MOS)-qualified soldiers, the training requirements of these organizations will increase.

The specific impact on training varies considerably by system in each spiral-out. Spiral 1 will have a modest, but still significant, impact if Intelligent Munitions Systems (IMS) and UGS are both placed in and used by maneuver platoons and companies. Although NLOS-LS and NLOS-C are not currently programmed to be spiraled out to the BCT, the impact would be larger if these systems were fielded to BCT field artillery battalions, as this would add a new vehicle system to the brigade, complicating maintenance and sustainment. Since these are primarily upgrades to existing C4 systems, Spirals 2 and 4 will likely have a more limited impact, which would be proportional to the difficulty of operating, using, and maintaining these new C4 systems and to the increased pace and scope of operations these systems make possible.

Spiral 3 has the largest potential training impact. Maneuver unit leaders and soldiers will be required to operate, effectively use, and maintain the new UGVs and UAVs. While maneuver units have some similar systems now, Spiral 3 greatly enlarges the number, and appears to involve normal use at lower echelons.

The enhancement of C4 systems is common across the spirals. These enhancements might not add to the training requirements of individual units. BCT concepts currently require effective use of C4 systems, and it is possible that the advanced FCS systems could be more capable and easier to operate, thus making training easier. However, for the training system as a whole, the greater the number of different systems fielded, the more training material and courses will be needed to support system training.

Training Implications in Critical Task Areas

Combined, the new unit designs, operational concepts, and modernization have the following effects in specific task areas, as shown in Table 2.2. The table shows the results of our review of the organizational design and concepts, which identified task areas that are both inherently difficult for training and the areas in which the FCS BCTs will pose an increasing challenge. The FCS will pose an increasing challenge in part because many of the tasks associated with the systems and the concepts that go with them will be done at lower echelons than today (thus involving leaders with less experience), with more austere organizational designs, and against a more difficult set and greater range of METT-TC conditions. In addition, the O&O is envisioning a higher training system performance level, e.g., being able to operate under the "train-alert-deploy" paradigm.

Table 2.2
Training Implications of FCS-Equipped BCT Unit Designs, Operational Concepts, and Technologies

Issue	Why an Increased Challenge for FCS-Equipped BCTs
Synchronization	• Required at lower echelons • Greater numbers of sensors, combat multipliers • Faster-paced operations
Precision fire	• Fire support elements will be less well-manned • High expectations
CSS synchronization	• Austere CSS structure • Widely dispersed, fast-paced operations
Engineer MCS functions	• Engineer staff only at FCT-equipped BCT level; no organic engineer or EOD organizations
Protection for CS and CSS	• FCS-equipped BCT AO greatly enlarged • COE threat will attack CS/CSS • CS/CSS organizations smaller
Increased C4ISR	• FCS-equipped BCT has far more systems and requires operations by soldiers/leaders with other MOS

Training Implications of ARFORGEN

The ARFORGEN strategy establishes a timeline for achieving some of the training demands of BCT programs as described above, and generates several potential implications of its own.

Reset/Train Pool. During the reset/train period, a BCT receives the personnel to allow for three years of personnel stabilization, and it conducts individual through BCT-level training to be ready for operational deployment if required. It is also likely that BCTs will receive spiral-out technologies and will modernize and modularize during this phase.

An underlying goal is to move out of this pool and into the ready pool as rapidly as possible so that as large a number of BCTs as possible are available to support ongoing or emerging operational requirements. However, accomplishing an adequate reset/train within the given timeframe will be difficult, especially because of the need to complete many steps in a short time, including reset, reorganization (receiving and assigning new personnel), and modernization (including C4ISR) and other new equipment operator, maintainer, and leader training.

The reset/train phase also needs to include sufficient time for recovery activities following a prolonged operational deployment.

The time required for modernization, just by itself, can be significant. Conversion from M1A1 to M1A2 tanks generally takes units about two months. Initial digitization training of BCTs and FCS-equipped BCT operators, maintainers, and leaders also requires time, and this training must precede collective training. Current NETT/DTT (New Equipment Training Teams/Doctrinal Training Teams) digital operator and leader training courses have one- to two-week Programs of Instruction (POIs), and around 1,200 personnel in a BCT will require this training.

Ready Pool. The training programs following reset/train should, to the degree possible, address the deficiencies identified during the train phase in order to make necessary improvements. Also to be considered is that the training during reset/train will, by necessity, cover a relatively narrow range of METT-TC and likely be focused on a "Base Mission Essential Task List (METL)." To help units attain "adaptability" skills, training during this period should add a greater range of missions and conditions, with focus on directed wartime missions or planned operational deployments.

The need to be ready for immediate deployment to an unforeseen contingency or to be as prepared as possible for a specific operational mission will also generate the need for a continued major training effort. Moreover, as there is limited understanding of skill decay under such a construct, current experience suggests that frequent digital sustainment training will be a requirement. However, it may be possible that units in this phase could assist in training other FCS-equipped BCTs.

Available Pool. One lesson of the current deployments is that focused training will still be needed after an alert. While the goal is for units to be ready for a Train/Alert/Deploy paradigm, the training system must have the capability for a paradigm that looks more like Train/Alert/*Train*/Deploy/*Train*. Experience has shown that the time to prepare for operational deployments can vary considerably. Preparation for peacekeeping in the Balkans took three months and included a CTC MRX (mission rehearsal exercise) to mitigate risk. The 3rd Infantry Division (ID), directly or indirectly, prepared for deployment for over a year. In contrast, initially deployed units had very limited time to prepare for the initial Operation Enduring Freedom (OEF) deployments to Afghanistan.

While immediate deployment might be required, it is obviously preferable to include an effective postalert/predeployment program. Training support for this phase can be critical to effective preparation. There are also many activities besides training that a unit must undertake to prepare its personnel and equipment for deployment. In addition, because threats evolve and conditions change during a deployment, the training system needs the capability to provide training support to units in theater.

Implications for Design of New Training Strategies

The implications of the findings discussed in this chapter are that training strategies, and importantly the ability of the training system to support this strategy, must continue to evolve, and that changes are needed, especially to improve the capacity for full-spectrum training.

Given that the operational requirements that were the genesis of ARFORGEN are expected to continue through the period addressed by this report, the training strategies for the FCS-equipped BCT will most likely be based on those emerging from ARFORGEN refinement. At the same time, enhancements will need to effectively leverage the capabilities of FCS technologies and apply them to full-spectrum operations.

The training system must also be sufficiently adaptable to rapidly develop mission rehearsal capabilities to support follow-on forces involved in unplanned contingencies, and capable of supporting in-theater training to adjust to changed missions and other METT-TC conditions.

CHAPTER THREE

Challenges for Current Army Force Training Strategies

In this chapter we present an empirical evaluation of the Army's current training strategies. Understanding the effectiveness of today's strategies provides the necessary foundation for developing new programs designed to achieve higher training goals. This chapter draws upon research completed during the first year of this project as well as other prior and ongoing RAND research.

There are two parts to this chapter. First, we turn our focus to the operational domain, reporting research results from two studies of 2001–2002 training programs. One study analyzes the type and frequency of the leader and collective training exercises actually conducted in the training programs of heavy units during 2001–2002, while another study focuses on National Training Center (NTC) performance levels achieved during the same period. Second, we present findings from our recent exploration of the general directions in post-2002 heavy-unit training programs since the deployments to Iraq began.

The findings from these analyses shed light on future training program needs. The analysis of 2001–2002 programs allows us to identify areas for improvement within current programs (including leader and collective training exercises) and, in turn, to identify potential changes in the current strategy needed to meet future requirements. Results from the analysis of NTC performance allow us to assess the effectiveness not only of unit training programs, but also of institutional and leader- or career-development programs of the larger training system, whose outputs also are reflected in NTC performance. The analysis of training strategies since the deployments to Iraq began shows how the training direction changes in preparation for a specific, high-intensity SOSO mission; these findings provide some indication of how the current training system will need to change in the future to allow commanders to train in an environment with high rates of deployment.

Content and Output of Unit Training Programs 2001–2002

We now discuss results of two recent RAND studies focusing on unit training programs in 2001–2002. The basis and methodology for these studies is shown in Table 3.1. Additional information about each study is included at the beginning of the section describing the results of that study.

Findings: 2001–2002 Heavy Unit Training Program Content

We first present results from the 2001–2002 study of heavy unit training programs. This study was conducted by RAND in 2002–2003 to look at the operational tempo (OPTEMPO) program for the Army G-3.[1] This study included in-depth examination of the FY01 and FY02 training programs of two heavy and two light divisions, as well as the two heavy BCTs stationed at Fort Riley, Kansas. The full study sample included 36 battalions, of which 21 were heavy and 15 light. We compared the training programs carried out by these battalions to those outlined in the Armor and Infantry Schools' CATS for the same types of units. To document the content of these training programs, we went to the division and brigade levels to collect training records and plans, cross check, and interview relevant personnel to resolve apparent discrepancies and inconsistencies. The result was a reasonably accurate database of the training events units conducted over the period examined.

[1] These findings are contained in an unpublished report by Lippiatt et al. on collective training resources and unit readiness.

Table 3.1
Methodologies of Previous RAND Research Supporting Examination of 2001–2002 Unit Training Programs

Battalion Training Programs	NTC Unit Training Proficiency
• FY01–02 • 36 battalions: 21 heavy, 15 light • Multiple data sources, including – Brigade Quarterly Training Briefs (QTBs) – Simulation Center logs – Division training regulations – NTC prerotational surveys – Interviews with unit leaders and unit/school training staff – Executive Summary Combined Arms Training Strategy (CATS) for the Tank Battalion (Force XXI)	• FY98–02 • Quantitative indices developed and applied in a series of projects sponsored by U.S. Army Forces Command – Training Analysis and Feedback Facility (TAFF) data – OC questionnaire data gathered at every change of mission (Covers more than 30 unit types, complete range of major function, approximately 100 skills per questionnaire)

Figure 3.1 and Table 3.2 show data related to units' training programs over the period studied. The figures show the annual average number of specific types of collective and leader exercises conducted by tank battalion programs[2] as compared to the number outlined in the Tank Battalion CATS.[3] Figure 3.1 provides a graphic image, while Table 3.3 shows the same data in tabular form.[4] Table 3.3 groups events into leader exercises, collective exercises, and gunnery. Leader exercises and collective exercises are further divided into live events and virtual and constructive simulation events. The figure shows the data at a higher level of aggregation than found in the table.

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2 In determining these averages, we did not include the time units were deployed or going through major modernization events. Nor did we include the events conducted during these periods.

3 There are several versions of the Tank Battalion CATS. The number of events in this figure are from the "Executive Summary for the Tank Battalion (Force XXI)," dated 14 May 2003.

4 Simulation-supported leader training exercises include CPX and LTP. Field leader training exercises include fire coordination exercise (FCX) and command field exercise (CFX). Collective field includes CTC, field training exercise (FTX), situational training exercise (STX), lane training exercise (LTX), and combined arms live fire exercise (CALFEX), platoon through BCT.

Figure 3.1
Content of Tank Battalion Tactical Training Programs 2001–2002 Compared to CATS

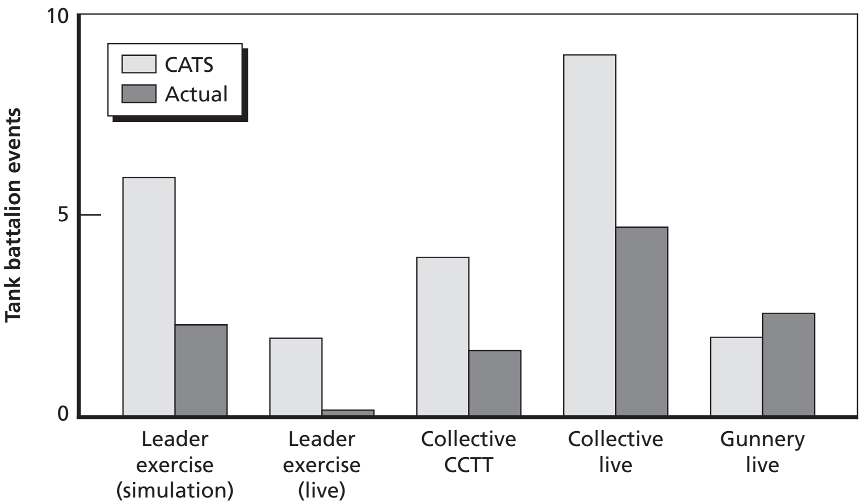

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Table 3.2
Content of Tank Battalion Tactical Training Programs 2001–2002 Compared to CATS

Event	Annual Frequency: Actual Bn Programs	Annual Frequency: CATS
Gunnery Tables	2.6	2
CALFEX	0.4	1
Platoon Lanes/STX	1.7	3
Company STX	0.8	3
Battalion/Bde STX/FTX/NTC	1.3	2
OPFOR Bn/Co	0.5	0
CCTT STX Co/Plt	1.7	4
CFX/FCX – Field	0.2	2
CPX/MAPEX Const Sim	2.3	4

The figure and table show that heavy units performed far fewer training events over the period than recommended by CATS. The figure and table show that tank battalions conducted only about three company- and platoon-level situational training exercises (STX) per year, fewer than half of what is called for in CATS. They conducted a third fewer battalion-level STX/field training exercises (FTX), including CTC rotations. They also did very few fire coordination exercises (FCX) or command field exercises (CFX). Units did conduct some field training events that are not in CATS, e.g., serving as opposing force (OPFOR) for other units' STX and FTX. We treated these as separate types of events, because they seldom offer units the opportunity to practice the full range of battlefield operating systems (BOS) functions to the same extent as the other events.[5] The number of events conducted for Bradley Fighting Vehicle (BFV) infantry battalions (not shown) were almost identical, with one exception, which we discuss later. Even though units performed considerably fewer field events than called for in CATS, on average they spent almost 100 days a year in the field because they spent many more days (and also more OPTEMPO miles) per event than called for in CATS.

Tank gunnery was the only type of training for which tank battalions conducted more exercises than called for in CATS (averaging 2.6 compared with 2.0 per year). This difference occurred mainly because units scheduled make-up gunnery to maintain the crew qualification rate in the face of crew turbulence. This make-up was necessary, especially before assumption of Division Ready Brigade (DRB) duties or before an NTC rotation, since qualification is required for deployability in the DRB or to participate in the live-fire phase of the NTC rotation.

The units we examined also did far fewer virtual and constructive simulations than called for in CATS. Simulations have a key role in the emerging training strategy for the FCS-equipped BCT. An average

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5 There are other battalion events in CATS that we did not include, mainly deployment exercises (Deployment Exercises [DEPEX], Sealift Emergency Deployment Readiness Exercises [SEDRE], Emergency Deployment Readiness Exercises [EDRE]). We found that these exercises are not scheduled events for most units; rather, they are included in major battalion exercises, such as Battalion FTX, or CTC rotations, or not conducted by most battalions.

battalion did only two and one-third constructive simulation events, only 40 percent of the number recommended in CATS, and one-third of these were conducted during the NTC's Leader Training Program (LTP). The typical tank company did about one and a half company or platoon close combat tactical trainer (CCTT) events a year; BFV companies did only about half this number, the one exception to otherwise almost identical event averages.

We also found that heavy tank and infantry battalions in 2001–2002 did a large portion of the home station tactical training during the period just preceding an NTC rotation, thus diverging from the recommendations of FM 7.0 and CATS, both of which call for a "steady-state" program across the training cycle.[6] Table 3.3 illustrates this point in tabular form, while Figure 3.2 provides a graphic version of the same data. In Figure 3.2, events are listed along the bottom, and divided in each column into those that were conducted during the seven-month ramp-up to the NTC rotation (including events in the rotation itself), and those conducted during the 18-month period outside the ramp-up. Units generally spent approximately seven months doing such a ramp-up. This means that most of the tactical training occurred in an eight-month period (CTC rotation, including deployment and redeployment and ramp-up) of a two-year cycle and very little occurs during the remaining 16 months.

Preparation for the NTC was intense, but the intensity of training dropped off after the NTC rotation, likely leading to a drop in readiness. During the NTC ramp-up, battalions typically had one platoon STX period of just under two weeks, a company STX period of about the same length, and a battalion or BCT STX period of over a week. Battalions also conducted two to four battalion or BCT constructive simulation-supported CPXs (command post exercises), including U.S. Army Force Command's (FORSCOM) Leader Training Program (LTP).[7] Additionally, some battalions did a bat-

[6] See the discussion "Train to Sustain Proficiency," Chapter 2, FM 7-0.

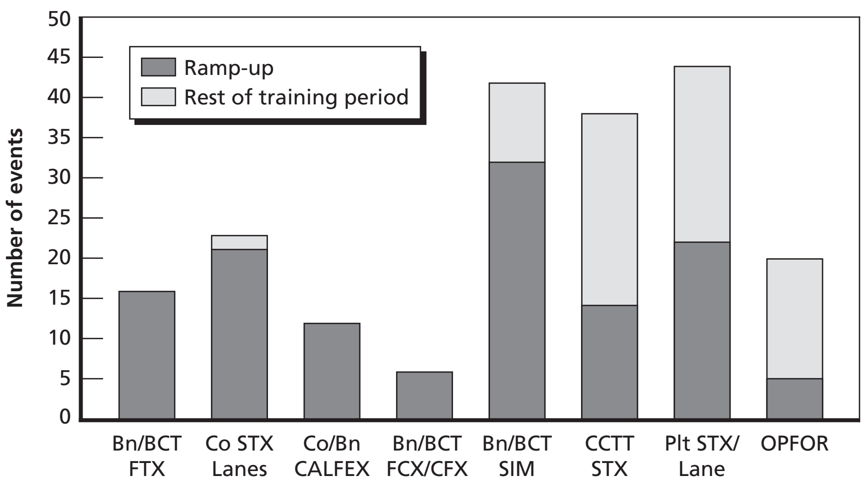
[7] The LTP was a week of instruction and training provided by the JRTC and the NTC Operations Groups to a brigade's leadership to support their preparation for the rotational training.

talion- or BCT-level FCX, CFX, or combined arms live-fire exercise (CALFEX). Ramp-ups also included gunnery qualification through Table XII qualification and a "make-up" gunnery qualification. Most of the leaders we talked to said they achieved as much as possible during their preparation programs and that such an extensive training period was necessary to be reasonably prepared for an NTC rotation.

Table 3.3
Percentage of Heavy Battalion Training Events During an NTC Rotation and Its Ramp-Up

Event	Percentage of Home Station Tactical Training Completed
Bn FTX/STX	100
Bn/BCT CPX/MAPEX	76
Bn/BCT/FCX/CFX	100
Co Lanes/STX/FTX	91
CALFEX	100
Plt Lanes/STX	50
OPFOR	25
CCTT STX	37

Figure 3.2
Number of Heavy Battalion Training Events During an NTC Rotation and Its Ramp-Up



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In contrast, between the NTC rotation and the next NTC preparation period, field force-on-force and simulation training was considerably less intensive, with platoon STX, CCTT exercise, and OPFOR constituting the primary tactical sustainment exercises. Unlike the tactical maneuver training events, the gunnery programs were generally "steady state," with gunnery qualification consistently done every six months.

During our discussions with units, we consistently heard that unit training proficiency began declining by about three months after the rotation. Especially when considering positional and unit turnover, we conclude that it is unlikely that units were able to maintain the same high readiness levels during the remaining three quarters of the cycle, when they trained less intensively.

Findings: 2001–2002 Light Infantry Training Program Content

An additional perspective on the training programs for heavy units can be obtained by comparing the training programs for heavy units with those for light units.

We found that the training programs of light battalions provided for ongoing sustainment rather than high levels of proficiency immediately following a CTC rotation. The light infantry training programs we reviewed differed significantly from those of tank and BFV battalions. Light training programs consisted of a cycle each with three distinct four- to eight-week phases: (1) a support phase with post-support, individual training, and similar activities; (2) a training phase with collective training of squad through brigade activities; and (3) a deployment phase in which the focus was on preparation for quick deployment and which included practice deployment activities. In light BCT programs, an NTC or JRTC rotation was typically the major training event conducted during one training cycle. While some CTC preparation training took place, light battalions did not conduct the extensive ramp-up CTC preparation programs we observed in the heavy battalions.[8]

[8] Heavy BCTs also had training cycles with three periods in each, a GREEN, a RED, and an AMBER. In a GREEN period the BCT had priority for training areas, and in RED periods they supported various installation requirements. The difference between the light and the heavy units was that during the GREEN periods (other than the one directly preceding

Light battalion training cycles were shorter and trained a selected set of METL tasks. Before an NTC rotation, heavy divisions executed a CATS-like set of events, gunnery through BCT FTX, and trained a complete set of mission-essential task list (METL) tasks. Light unit home station programs, like those of the 82nd and 101st Divisions, emphasize movement to contact against a JRTC-like threat and offensive MOUT. The 101st emphasizes air assault operations. The 82nd Airborne focuses on the assault of a lightly defended airfield and defense of an airfield against light reaction forces.

Light battalions did almost no simulation training. Also, while heavy brigades had limited simulation training, light brigades did almost no simulation-supported exercises outside of LTP at the CTCs and participation in divisional or corps-level Battle Command Training Program (BCTP) exercises.

Findings: 2001–2002 Unit Training Program Output

We next look at the output of the 2001–2002 training programs as seen in the NTC Unit Training Proficiency Study. This is an ongoing study for FORSCOM to measure training performance of units at the NTC and Joint Readiness Training Center (JRTC). The results reported here are taken from a recent report from that project.[9]

To obtain the data, RAND collects observer/controller (OC)[10] questionnaire data covering almost all of the organizations of a BCT at platoon level and above during the course of a rotation.[11] Each organi-

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the NTC rotation), heavy BCTs seldom trained higher than platoon level, whereas light BCTs always included battalion or BCT-level exercises.

9 The results are taken from an unpublished report by B. Hallmark et al. on using CTC data as a tool for assessing training.

10 At the CTCs, trainers accompany the rotational units being trained. They observe the unit's operations, enforce rules of engagement, and provide training feedback during after action reviews and through one-on-one suggestions to rotational unit leaders. The title on the operations group TDA is "observer trainers," but these individuals are universally called "observer/controllers" (OCs). In this document we use the abbreviation OCs.

11 RAND also examines various data collected by the tactical analysis feedback facility for AAR purposes, including number died of wounds, Operational Readiness rates, and field artillery and mortar firing logs.

zation is rated on a range of key skills, tasks, and functions across the various BOS at each change of mission. Up to 100 items are rated for each organization. Results reported from this study are based on an average across almost three years of rotations. An explanation of the rating system used is found in Appendix A.

Results from the study show that for most units, performance of the large majority of tasks was not adequate the first time a task is performed. This indicates that the home station training these units conducted was not sufficient to achieve full training proficiency.

The study does indicate, however, that the more frequently activities were conducted, the higher the percentage of units that reached proficiency. This finding supports the belief that multiple iterations (i.e., a greater quantity of training events) are important to develop the ability to successfully perform combat skills under difficult conditions.

NTC performance results were less positive for maneuver battalions and BCTs than for maneuver platoons and companies. In the higher-echelon units, fewer than half of the critical skills were ever performed at adequate levels by most units. This was likely the result of multiple factors.

- A higher percentage of maneuver battalion tasks appear to be inherently more difficult than tasks for platoons and companies. A key reason for this difficulty appears to be that maneuver battalions and BCTs have to perform tasks with more types of elements under their control. The idea that the difficulty of performance is related to the number of subelements is supported by the performance of BFV platoons compared with the performance of tank and light infantry platoons. BFV platoons have to manage two systems that must work together: fighting vehicles and dismounted infantry elements. Tank and light infantry platoons, on the other hand, manage only one system. These dual systems possibly contribute to BFV platoon underperformance compared with tank and light infantry platoons.
- The percentage of skills not performed adequately is also probably a consequence of the fact that battalions and BCTs do fewer

iterations than platoons and companies during the course of their training programs.

Synchronization and other key skills were lower for units at all echelons. Finally, the data show that certain types of skills tend to be challenging at all levels, from platoon through BCT. These skills include direct fire skills, synchronization of combat multipliers, fire support execution, and intelligence exploitation. All of these are key to successful execution of future training concepts.

Figure 3.3 shows a detailed example of how skill areas are assessed. The example looks at battalion skills related to Combined Arms Maneuver synchronization and integration, a key skill area for the FCS-equipped BCT. Fifteen skills are measured in the table, including those related to both planning and execution. The figure shows the details behind the broader statements made earlier. The first column of numbers shows that fewer than 50 percent of the units were able to perform any of the skills at an adequate level on their first try. Moreover, although there was some improvement during the rotation (see the right-hand column of numbers), fewer than 50 percent of the units were able to perform more than half of the skills at an adequate level by the end of the rotation (see the middle column of numbers).

Heavy BCT Training Programs Since FY02

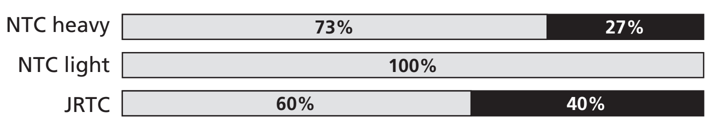
We now discuss some results from our examination of training programs in the recent past, after the beginning of the Iraq deployments. The findings discussed in this section are drawn primarily from a review of training data collected from the 3rd and the 4th Infantry Divisions, as well as a limited set of interviews and discussions with training staffs in these divisions, in the 1/25 Stryker Brigade Combat Team (SBCT), and at the NTC and JRTC.[12]

12 We did not examine the training program of the 1/25 SBCT, but we did conduct focused group interviews with commanders and training staffs in this brigade.

Figure 3.3
Light Battalion Performance of Critical Combined Maneuver Synchronization Skills, Tasks, and Functions

	Battalion skill	First score Percent of units better than 2	Best score Percent of units better than 2	Percent of units improving
Plan	Plan to achieve favorable force ratios	20	55	50
	Plan to optimize mutual support	20	64	70
	Plan for massing effects	20	55	70
	Plan for isolating enemy	20	36	50
	Plan for employment of reserve	20	36	50
	Conduct wargaming (command/ staff present)	30	64	40
	Plan to provide flexibility (e.g., branches)	10	45	70
Execute	Maneuver to achieve favorable force ratios	40	64	50
	Optimize mutual support	10	27	50
	Mass effects	10	27	50
	Isolate enemy	10	27	60
	Employ reserve	10	45	40
	Maintain operational tempo and momentum	10	27	40
	Maintain mutual support among its elements	10	36	50
	Coordinate adjacent/supporting/ supported organizations	40	45	30

Distribution of Bn TF synchronization and integrate skills at best score



RAND *MG538-3.3*

Our data and research effort concerning the training programs for these two divisions was much more limited than that done to review heavy BCT programs in the 2001 timeframe. For the effort discussed here, we were able to collect and review most but not all Quarterly Training Briefs (QTBs) covering the periods between deployments (these did not exist for some periods). We also reviewed division-level calendars and division quarterly training guidance. These were complete for the periods but lack the detail of QTBs. We also collected several partial (none complete) sets of simulations center exercise logs. Given the operational requirements, we were not able to interview brigade and battalion training staffs as was done for the examination of training programs prior to OIF, but we did interview selected division-level training staff members.

Summary of Divisional Post-OIF Training and Readiness Programs

Although the overall requirements for both divisions were similar, the specifics of each division's training and readiness programs were different.

3rd Infantry Division. The period between the 3rd ID's return from Iraq and its redeployment was approximately 16 months, from August 2003 until January 2005.[13] During this period the division was not only recovering from its first deployment and training to regain training readiness for both conventional and stability operations, but was also reorganizing into the Army's new "modular" concept and modernizing its digital command, control, communications, and computer equipment.

The reorganization requirement was extensive, especially considering that this was being done in conjunction with recovery from operations in Iraq. Also complicating the reorganization was the fact that the modular organizational concept had only recently been developed, and specific organizational designs evolved as the division reorganized. The division only partially achieved approved modular organization prior to its return to Iraq. There are major organizational and personnel

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[13] This timeframe varied depending on the specific brigade's return and redeployment schedule.

differences between modular and nonmodular BCTs. The maneuver battalions are combined arms (CA) rather than pure tank or infantry, meaning that each CA battalion has both tank and BFV companies and also has an organic engineer company. The BCT has an Armored Reconnaissance Squadron (ARS), rather than a Brigade Reconnaissance Troop.[14] The BCT also has a Brigade Special Troops Battalion, which includes elements such as military intelligence, signal, and military police, which were formally under separate divisional-level battalions and companies. Additionally, the division has a fourth maneuver BCT. Thus, the makeup of equipment and personnel specialties was considerably different. Moreover, required personnel and equipment arrived throughout the period, further complicating the reorganization and making it one that greatly impacted on the execution of training programs.

The first two to three months after return to home station chiefly involved modular reorganization and redeployment activities, such as drawing equipment from storage, recovery of and accounting for returning equipment, re-establishment of garrison facilities, block leaves, and other recovery activities that would be expected after a lengthy operational deployment. There was emphasis on reintegration training and activities, the program of reintegrating soldiers into home life and with their families. Likewise, the last two months at home station were devoted chiefly to direct preparation for deployment. Thus, the time available for collective training was limited to 10 or 11 of the 16 months the division was at home station.

Garrison and other support requirements also affected the time available for training. At any given time, garrison support requirements require a major portion of one brigade. Additionally, given the heavy commitment of deployed or immediately deploying units during this period, there were many support requirements from FORSCOM; for example, there had to be a company team ready for immediate reaction to an unforeseen operational requirement.

[14] For more detail, see "Army Comprehensive Guide to Modularity," Headquarters TRADOC, dated 8 October 2004.

A requirement that had a major impact on the time available for training was the support of NTC and JRTC rotations with OPFOR, training support, and "augmentee OCs." The CTC operations groups were not designed to support modularized BCTs, and extensive augmentation was required. Because of the heavy deployment of other FORSCOM units, the burden of supporting its CTC rotations fell on the 3rd ID itself, with the net effect of devoting a BCT to support each BCT being trained. Thus, the twelve months were far less available for training than would be indicated by the calendar.

The division trained for full-spectrum operations in order to be prepared for a range of operations from low to high intensity. The general training concept was to have the first part of the period devoted to training for major conflict operations, with an NTC rotation as a culminating event, and a second part devoted to training for stability operations in Iraq, culminating in a mission rehearsal exercise (MRX) at the JRTC, which was shaped so that it would, to the extent possible, directly prepare soldiers for an Iraqi mission. The JRTC training was different from the CTC rotations in the 2001–2002 timeframe in that about half the rotation consisted of company STX, rather than the entire rotation being brigade-level operations.

Even though the overall objective was preparedness for full-spectrum operations, there was a clear priority to train for the OIF mission, especially in the second half of the training period. In conjunction with the overseas commanders, FORSCOM directed an extensive amount of individual, leader, and collective training in preparation for this mission.[15] The division's training guidance emphasized these and additional individual, leader, small-unit combat, and other skills needed to support stability operations in Iraq, including the need for small-arms and self-defense skills across combat support and combat service support organizations as well as maneuver units. For example,

[15] These requirements were listed in a series of messages from FORSCOM G-3 Central Tasking. For example, "Training Guidance for Follow-On Forces Deploying International Security Operations (ISO), Operation Iraqi Freedom," dated 6091409Z September 2004, listed an extensive set of individual and collective training requirements and included language and Iraq orientations.

small-arms training increased “reflex fire” and “shoot house” type tasks compared to pre-OIF marksmanship programs.

A calendar outlining the division’s training program is shown in Table 3.4. This calendar is simplified, showing only major training events such as gunnery periods, and platoon-and-above collective training events. The calendar shows the month in which the majority of the training event for the BCT took place. Many events on the QTBs are not included, as these varied extensively by battalion and would be complicated to present. Likewise, many of the individual and squad-level training needed for OIF preparation were not shown on QTBs, but required extensive and repetitive training. Thus, the first impression provided by the calendar—that during many months there is no ongoing training or other major activities—is far from the case. Our review of the more detailed QTB data along with our interviews of the division personnel all support a contention that this was an extremely intense period for the division.

The division conducted tank and BFV gunnery twice, but during the last half of the training period, gunnery was geared toward crew- rather than platoon-level qualification. Additional gunnery training included “OIF gunnery,” which incorporated special marksmanship training, an Iraq-focused live-fire exercise, and convoy LFX.

The training programs varied by BCT. The collective training programs were on a staggered start, with some overlap, but generally one BCT at a time. The first two brigades had 5 or 7 days of platoon STX, 5 days of company STX, and a battalion FCX event prior to the NTC. The NTC itself had a mix of MCO and SOSO operations at BCT level, and no brigade live fire. These BCTs also had a JRTC OIF-focused MRX rotation, with about half devoted to company STX and half brigade operations. Both BCTs had a platoon/company-level SOSO-oriented STX prior to the JRTC MRX.[16]

The third BCT had a more traditional, but still reduced, NTC preparation program consisting of 5 days of platoon STX, 5 days of company STX, and 7 days of battalion STX. The NTC rotation was an extended 4-week event. The first half was oriented toward major

[16] We do not have QTB data to verify the number of days in this event.

Table 3.4
3rd Infantry Division Training Calendar by BCT

	Aug–Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
1st BCT					LTP	Gun	Plt STX	Co/Bn STX		NTC		Gun OIF			
2nd BCT			Gun	Plt/Co STX	FCX	LTP		NTC		Gun		Plt/Co STX	JRTC		
3rd BCT		Gun	Plt/Co STX FCX	LTP	NTC			Gun	Plt STX		Gun LTP	JRTC			
4th BCT					Estab				Plt STX	Gun FCX	Plt/Co STX	LTP	JRTC		

combat operations (MCO), but still included SOSO events in the scenario. The MCO portion included battalion STX, brigade operations, and brigade live fire. For this BCT, there was no JRTC MRX nor additional platoon or higher-echelon STX after the NTC rotation.

The fourth BCT was established in January, more than four months after the division's return. Consequently, this BCT had a reduced training program compared to the other three BCTs. It had no NTC rotation. Like the first two BCTs, its JRTC was an OIF-focused MRX, with the first half consisting of company STX. This BCT did platoon- and company-level STX to prepare for the STX, but we have no detail on these events.

The modernization for the BCTs consisted of fielding of improved ABCS systems. This fielding occurred after the NTC rotations, and just prior to their JRTC MRX; thus, the BCTs had little opportunity to train on the use of these systems during collective training events.

4th Infantry Division. The 4th ID returned from Iraq in April 2004 and began its deployment back to Iraq in November 2005. Compared to the 3rd ID, the 4th ID has a somewhat longer period in which to train (20 months versus 16). This period occurred about one year after the training period of the 3rd ID.

The calendar of major gunnery and collective maneuver training events is in Table 3.5. The division's OIF preparation requirements were similar to those of the 3rd ID, and they had the same emphasis on individual, small-unit, and other type training needed for preparation for OIF. The 4th ID also had similar garrison and FORSCOM support requirements. It had major homeland security and operational contingency requirements that required significant unit preparation and leader planning.[17]

From May through December, the division focused on recovery, integration, reorganization, and individual through squad-level training, including all the activities described for the 3rd ID above. During

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[17] It was assigned two homeland security missions, responsibility for having a company team prepared for immediate deployment for an XVIII Corps contingency, having a BCT prepared for quick response to a contingency in Korea, as well as divisional responsibility to support war plans in Korea.

Table 3.5
4th Infantry Division Training Calendar by BCT

	Apr–Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1st BCT	Reset	Gun			Plt STX		Gun	Co STX		TF STX	FCX	NTC
2nd BCT	Reset	Gun		Plt STX	Co STX		TF STX	Gun	FCX	NTC		
3rd BCT	Reset Gun	NTC Spt				Gun	FCX	Plt/ Co/ TF STX			NTC	
4th BCT	—	—	—	Estab			BFV NET	BFV NET	Plt STX	Gun Plt STX	Co STX FCX	ETC

May and June, the major activities were block leaves and mandatory reintegration training. The division started collective training with gunnery for one BCT in October. The redeployment and restoration of equipment to mission-capable condition prevented the division from beginning collective training any earlier. Unlike the 3rd ID, the 4th ID had used its own major weapon systems in Iraq, and this extended its equipment recovery period compared to that of the 3rd ID. The division started M2A3 NET in October. This NET, which included gunnery, took about two months. Each battalion also went through a tank and BFV qualification starting in October.

The 4th ID had to exert major effort to reorganize into a modular organization, to include forming a 4th BCT. The 1st, 2nd, and 3rd BCTs substantially completed reorganization efforts by the end of December.[18] The 4th BCT was formally stood up in January, and was substantially reorganized by the end of March.

While modernization of tanks and BFVs was completed for three brigades by January and for the fourth by the end of May, an additional major modernization effort was upgrading to ABCS version 6.4. Although the division had been "digitized" prior to its first OIF

[18] The reorganization was not complete in terms of each BCT having all the personnel of the right grade and MOS branch, but it was complete enough that the division was able to start collective training.

deployment, the 6.4 was a major equipment and software upgrade, and considerable training was needed for about eight thousand divisional personnel. Adding to the magnitude of this mission was the fact that the system was a prototype and therefore needed continual functional modifications and operator training. Moreover, the division had responsibility for supporting the development and operational testing of this major new Army system. Overall, the ABCS requirements greatly complicated the division's training program execution.

As with the 3rd ID, BCT training programs for the 4th ID varied by BCT. The 1st, 2nd, and 3rd brigades in the division had a single NTC rotation and an NTC preparation program consisting generally of the same type and length of events as for the battalions we examined in the 2001–2002 timeframe, i.e., a platoon STX period, a company STX period, battalion Task Force (TF) STX period, and a brigade-level FCX. The NTC rotations were designed to exercise both stability and major conflict operations. During the entire rotation the BCT was in a continuous operations setting, in which stability operations were included, but about half the rotation consisted of brigade-level major conflict force-on-force and battalion-level live major conflict operations. In addition, the NTC provided convoy live-fire opportunities to the BCT throughout the rotation.

The battalion STX periods for these BCTs were considerably different from those of the pre-OIF period. During the period from 2001 to 2002, normally the entire NTC BCT was in the field executing a BCT-level tactical scenario. These exercises generally took 9 days or longer and were supported by trainers from a sister BCT, normally one recently returned from the NTC, thus providing for a reasonably experienced set of trainers who could pass on their own "lessons learned." OPFOR was also normally provided by an outside BCT.

For the 4th ID during the post-OIF period, home station battalion STX were about five days long and internally supported, with one battalion doing force-on-force, one operating as OPFOR, and one providing the OCs. This had advantages over pre-OIF procedures in that it allowed the brigade commander to be directly involved in observing and training his battalions, and provided a valuable training opportunity for the battalion providing the OCs. However, it also meant their OCs were less experienced, the brigade did not get the experience of tactically controlling multiple battalions, and the brigade's artillery and support battalions did not get the experience of supporting a full BCT.

The 4th BCT was not formed until January 2005. Except for one combined arms battalion, this BCT was essentially a new organization, formed from scratch. It started collective training with platoon STX in June and company-level STX in August. There was also a battalion FCX in August. Unlike the other BCTs, the 4th BCT did not have both a battalion STX at home station and an NTC rotation. Instead, it had a single three-week-long "embedded BCT" level live/constructive exercise, supported by the JRTC Operations Group. In this exercise, each maneuver battalion level did a five-day live STX, logistically supported by the support battalion, with the other BCT and battalion CPs in the field performing tactical command and control functions in a CPX supported by constructive simulation. The exercise included both major conflict and stability tasks in a tactical scenario that integrated both the force-on-force and CPX participants.

Except for the 4th BCT, 4th ID units had far fewer constructively supported home station battalion/BCT CPX (in which battalion CPs are the primary training audience) than was the case in the 2001–2002 timeframe. While each BCT participated and was a primary training audience for the division-level CPX and mission rehearsal exercises, battalion participation (and thus training benefit) was generally limited to mission planning skills during these events.[19] The division had planned a full BCT/battalion-level CPX for each BCT, but because of the overall requirements on the division, the trainer resources needed to support this requirement, basically a "sister BCT," were available only for the 4th BCT.

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[19] Two BCTs participated in a week-long command and staff training BCTC-supported event. This training was designed to train effective tactical use of the ABCS systems. Training during this week progressed from basic skills at integrated use of the systems, to tactical execution of operations in a tactical scenario. Also, the battalions of the 2nd BCT participated in the ABCS 6.4 operational test in a CPX mode.

Findings Post-2002 Training

Our review of the post 2002 BCT training programs was limited, but we think it has been sufficient to draw some macro-level findings that have potential important implications for future training strategies.

The most important finding is that time is the most critical constraint. This was true for the pre-OIF training programs and is even more true today. While we believe that these training programs were as extensive as reasonably achievable given the competing requirements, both the amount of time devoted to direct training activities and the amount of training events units were able to conduct were constrained by many nontraining requirements. A review of the training calendars indicates that less than half of the time was devoted to gunnery, platoon-and-above, force-on-force, and live-fire training, including CTC rotations.

Modernization, modularization, and deployment requirements have had significant impacts on training time available. Modularization required time to reorganize and effect changed manning and equipment TOEs. Associated with that effort is the unit time required for equipment turn-in and draw, which takes away from individual, leader, and collective training time. In both divisions, the training programs of the newly formed BCTs were less extensive than those for the other BCTs.

Upgraded ABCS systems required a NET-like program to introduce the enhanced C4ISR systems into the 4th ID, even though this unit was previously "digitized." The introduction of digital systems adds a requirement not only to train on these systems, but also to train to cope with situations in which the digital systems are not fully functioning or have been degraded by enemy actions.

Preparation and recovery from deployments had major direct and indirect impacts. The minimum time directly needed both to prepare for and recover from operations appears to be two to three months. Indirect effects of deployments severely affect the time available for training. Nondeploying units were called upon to support deploying and deployed units, including assumption of their missions and support requirements.

During our discussions with members of both divisions we were told that the number of requirements was complicated by changes in all these programs. The mission of preparing for the OIF deployment was complicated by the changing requirements for that mission. Modernization schedules changed or shifted continuously. Personnel replacements to fill the new organizational structures were not fully accomplished. This meant that not only was the time available for training constrained, but also the ability to optimize the available time was degraded.

Training areas will also limit the amount, type (e.g., MOUT), and echelon of training possible at home stations. These limitations were described as being a key reason why the 4th ID was not able to conduct force-on-force training for more than a single BCT at a time.[20] If maneuver areas were an issue at the relatively large Fort Hood installation, this issue will be even more of a factor at smaller installations, especially in light of the larger maneuver areas needed for FCS-equipped BCT operations.

Expanding training goals from a focus on major conflict to full-spectrum operations greatly increases training requirements. Training for the lower end of the conflict spectrum is difficult and demanding. Specialized training programs, including CTC mission rehearsals, have been set up to prepare units for these deployments. Three-month preparation programs are in place for the relatively stable peacekeeping operations in the Balkans. Far more extensive preparations are being implemented to prepare units for deployment to Iraq and Afghanistan. While the risk of *tactical* defeat in these SOSO is low, the overall training requirements for *operational* success are high. Moreover, training that is critical for success in high-intensity operations can be inappro-

[20] That is, there is maneuver area at Fort Hood for one BCT "maneuver box." Prior to OIF, several BCT-on-BCT live training exercises were conducted at Fort Hood. These were "blue-on-blue" exercises, that is, ones in which each BCT used its normal organization and tactics. Thus, by using the same maneuver area, two BCTs were able train at the same time. But with the contemporary operating environment, the OPFOR uses considerably different organizations and tactics from those of a BCT. Thus, the same maneuver area allows only one BCT to now train at a time.

priate for lower-intensity operations.[21] Finally, increased self-defense needs in an insurgent environment generate new and demanding training requirements, including convoy counter-ambush and counter-IED training.

Replication of the contemporary operating environment (COE) METT-TC at home station and even the CTCs is difficult. Creating a realistic OPFOR is not just a matter of simple modification of normal tactical methods used for pre-OIF MCO-type training. There is a need for an increased number of role players. Moreover, assuming that even for high-intensity conflicts a future threat will use asymmetric tactics, the close terrain and large number of dismounted OPFOR needed for higher-echelon training will be a challenge to obtaining training realism.

The goal of achieving full-spectrum readiness generated considerable differences in training programs of BCTs in these divisions compared to those of pre-OIF heavy BCTs. Although the same general types of training events were conducted, the balance of type events and METT-TC conditions differed. Key changes included:

- Far more emphasis and time were devoted to individual, leader, and squad- and platoon-level training, including for live fire (shoot houses, reflex fire, etc.). This was especially true for non-maneuver units.
- Collective live-fire exercises, including convoy training, were seen as key components of COE training programs. Many trainers said that currently available ranges and targetry need great improvement in this area for increased realism and throughput.
- There was great demand for virtual convoy live-fire trainers and for small-arms trainers (Engagement Skills Trainer, or EST).
- Both divisions experienced difficulty performing higher-echelon training at home station. "Sister unit" BCTs were not available for battalion-level training. In the 3rd ID, only one BCT did home

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[21] For example, tactics, techniques, and procedures (TTP) for clearing a room in an urban area defended by conventional enemy forces would be totally unsuitable for clearing a room occupied by noncombatants in a cordon-and-search operation during a stability operation. (The task is the same, but the TTP given the conditions are very different.)

station battalion-level force-on-force training. For the 4th ID, three of the BCTs did battalion-level STX, but this training was somewhat shorter, executed at battalion rather than BCT level and was self-supported internally by the BCT.
- There was limited CPX training supported by constructive simulations with battalions as a primary training audience. There were none conducted at home station for the 3rd ID, and few for the 4th ID. Lack of trainer support seems to have been a key contributing factor, at least for the 4th ID. Moreover, trainer support needs for such exercises (needs that include digital higher and adjacent units, role players, and manual event injections) have increased with COE and modernization.
- Units seem to be relying more heavily on CTCs for preparation training. For example, many units are requesting that CTCs provide lower-echelon lanes training for the first part of the rotation rather than going directly into BCT operations. Further, the 3rd ID did two CTC rotations to prepare for deployment.

The ability of the institutional Army to respond has been limited by resources. There are few doctrinal and no training support materials for the modular BCTs. Current doctrinal and training materials for SOSO or digitized operations do not address these subjects to any level of depth.[22] CTC enhancements to address digitization and changed SOSO needs have been slow to come on line, and those that have so far reflect the great initiative of the staff at the CTCs and others supporting those programs.

[22] As an example, UAMBL's training work group performed an analysis of the collective tasks required for the FCS-equipped BCT. They found many tasks that have not yet been developed by TRADOC. When we reviewed this listing we found that it identified only a small number of truly new tasks directly related to FCS capabilities. The majority of the "new" were ones that actually currently exist (that is, ones needed by today's BCTs) but that had not been developed by TRADOC.

Implications for Design of New Training Strategies

The current period of high deployments provides a good environment for assessing how far the Army needs to go to meet the training requirements of the future. It seems apparent that the Army's training system is under stress to support the expanding range of operational missions in the COE, and, at the same time, to implement modularity and modernization of C4ISR systems. Training requirements are increasing, whereas training resources, especially time to train, are decreasing. Our research indicates that SOSO training requirements are difficult and demanding and that they generate new training requirements. Indirect effects of deployments severely impact the time available for training, while the ability of the institutional Army to respond to the expanded set of training requirements has been limited by resources.

This examination of both pre- and post-OIF training programs has important implications for the design of new training strategies. The 2001–2002 programs show what sort of unit training was necessary to prepare for MCO missions. While the specifics of these missions have changed with the change in the operational environment, the concepts and limitations that shaped these training programs remain relevant. Our review of programs since 2002 shows the limitations of the training system in a period in which the focus has shifted to SOSO-type operations. The training system is also limited in terms of its ability to meet the type of heavy operational demands that are expected in the future environment.

This baseline research suggests where the Army needs to start, and where it is likely to experience the greatest challenges in achieving the higher training requirements of the BCTs and the FCS-equipped BCTs.

Overall, we see that, given the current training system, units will likely have difficulty achieving full-spectrum capability for all possible contingencies. In the future, the range of possible METT-TC that units need to be prepared for must be assumed to be large and subject to rapid change. Thus, any concept of being prepared for immediate operational reaction must be tempered to acknowledge that immediately responding forces, although they may be sufficiently prepared, are not likely to be *fully* prepared, and that the Army's training system must be adaptive enough to support both continued training in theater and adjusted, concentrated training programs for later-deploying units.

Current challenges suggest key training issues for the BCT and FCS-equipped BCT in achieving more demanding goals. In particular, our research indicates how the quality, quantity, and adaptability of training will need to improve to meet the strategic needs of FCS-equipped BCTs.

- **Improvements are needed in training quality, especially for simulation-based training.** RAND's CTC training research (FY98–FY02) shows that although many units perform most critical skills, tasks, and functions adequately at some point during the NTC rotation, it currently takes an entire rotation to reach full proficiency. The implication is that units find it difficult to devise sufficiently realistic and complex live training at home station. Moreover, performance of units at higher echelons (maneuver battalions and BCTs) lags behind that of lower echelons, and performance does not reach adequate levels in some significant skill areas, for example in synchronization and direct fire skills. While simulations are intended to address some of these deficiencies, the experience of units suggests that constructive simulations (and, to some extent, virtual simulations) are not sufficiently extensive and realistic to meet current unit needs, especially in training complex collective skills.
- **The quantity of training events needs to increase.** In order for units to reach future training goals of adaptability and the Train, Alert, Deploy paradigm, the Army may need to implement a larger number of events under a wide range of METT-TC. However, data from FY01–02 indicate that units are implementing significantly fewer events than recommended by CATS. Moreover, results show that a large percentage of company-and-above training events occur only during preparation for NTC events. Key to any large increase in quantity will be making more time available for training. It may be possible to do more training through increased use of constructive simulations; however, for a variety of

reasons, units did only 40 percent of the recommended number of simulation events during this period. The net result is that maintaining NTC-geared proficiency is suspect—with more than half the force likely at lower training levels during "sustainment." Programs since 2002 show training during a period in which the focus has shifted to SOSO-type operations and heavy operational demands. Our examination indicates that these training requirements are difficult and demanding, especially for implementation at home station, and that there is a large increase in nontraining requirements placed on units. As a result, training programs have tended to be less extensive than in the earlier period. Moreover, it seems clear that the Army's current training strategy is unable to support enough training events to prepare units for a wide range of contingencies.

- **Training needs to be more easily adaptable to meet the challenge of an adaptive enemy and to allow training to be delivered anywhere.** Recent experience suggests that perhaps the biggest challenge to the Army's training system will be to create a capability to rapidly adjust to the evolving threat and operating environment to deliver training anywhere, anytime. Current operations and FCS-equipped BCT experiments show that superior technologies can be countered by a competent, adaptive enemy, and that current operations demand competencies across a far wider range of skills than was the case when Army training programs could focus almost exclusively on MCOs. However, recent experience shows that adaptation of live-virtual-constructive (LVC) training events to multiple METT-TC is resource-intensive. Lacking the full range of resources needed, and full support from the institutional Army (e.g., for training and doctrinal support products), units are limited in their ability to use training to increase their adaptability.
- **There is a need for systematic data collection on actual training programs, their constraints, and their "output."** We have found no systematic effort being made to collect data, to any level of detail, on the actual structure (type, frequency, and duration of training events and activities) and constraints of unit training

programs. We believe that such an active effort would usefully supplement existing efforts to collect operational data from theater on the shortcomings and needs for training. Together these data would be of great benefit to support informed decisionmaking concerning training policies, training guidance, and programming training resources.

CHAPTER FOUR

Method for Identifying and Assessing Planned Training System Enhancements

In this chapter we explain our approach for identifying and assessing the major training enhancements for FCS-equipped BCTs in terms of their ability to address increased Army training requirements.

Our assessments estimate the extent to which currently planned training enhancements, with no augmentation or change, could, by 2016, fill the gap between the outcomes of today's Army training programs for FCS-equipped BCTs and emerging Army training requirements. We aim to illuminate the nature of the entire gap between today's outcomes and future needs in order to help the Army prioritize future training investments and achieve a balanced training strategy that maximizes capability within available resources.

Training Enhancements Identified

We identified and evaluated twelve major training enhancement categories, briefly defined below:

- **Enhanced live training technologies.** Planned improvements to the Tactical Engagement Simulation Systems (TESS), ranges and facilities, targetry systems, and instrumentation systems at home stations and CTCs.
- **CTC enhancements.** CTC modernization program, to include TESS, maneuver areas, and instrumentation system.

- **Enhanced virtual simulations.** Planned improvements in simulation supported training technologies, where real people are using simulated systems or equipment.
- **Enhanced constructive simulations.** Planned improvements in simulation-supported training technologies, involving the simulation of both the people/operators and the equipment they are using.
- **Simulation-based tactical skills trainers for leaders.** Simulations (either virtual, constructive, or a blend) that can be delivered via a laptop computer and that have as their goal the training of tactical skills to individual Army leaders or small groups.
- **Integrated LVC.** Planned initiatives to integrate different combinations of live, virtual, and constructive simulations to improve training accessibility or quality, or to increase the size of the training audience. Also includes initiatives to develop a set of improved, common support tools to support training across the spectrum of LVC simulations.
- **Embedded training.** Efforts to embed training technologies in operational equipment.
- **Training manpower support for home station training.** Planned increases in manpower resources that installations provide to support training events at home station.
- **Lifecycle manning.** Initiative under which units are stabilized for a period of 36 months.
- **Institutional training initiatives.** Proposed improvements in schoolhouse training to focus, decentralize, and increase the availability of individual training content and information from the institutional domain.
- **Collective training support products.** Proposed improvements in the primary products (current and planned) that TRADOC proponent schools provide to support collective training.
- **TRADOC execution of FCS-equipped BCT initial fielding.** TRADOC plans to support the initial organization, equipping, and training of FCS-equipped BCTs.

Some of the enhancement categories are defined in the UA O&O Plan and its supporting System Training Plans (STRAPs), while some represent other currently proposed training initiatives for enhancing future Army training strategies, including the Essential Training Complementary Programs identified by UAMBL.[1] The list of enhancement categories was decided on after multiple iterations. After our first round of interviews, we identified an initial list of nine enhancements. We then circulated our list among subject matter experts (SMEs), asking for input on enhancements missed or ones that needed to be better defined. As a result, we added two enhancement categories to the initial list and changed the names of several others.

Approach for Evaluating Training Enhancements

To assess the twelve training enhancements individually, we used the approach illustrated in Figure 4.1.

We began by considering available information (via interviews and reviews of requirements documents and other materials describing the training environment) about what the potential enhancement is designed to achieve compared to the current capability, as provided by the offices responsible for developing the technologies associated with each enhancement, the TRADOC counterparts to these offices, and other Army offices. We then considered what the enhancement would need to do to achieve the necessary improvement in training; to make this assessment we looked at future training requirements as well as our own analyses of current unit training programs and their CTC training performances (see Chapter Three).

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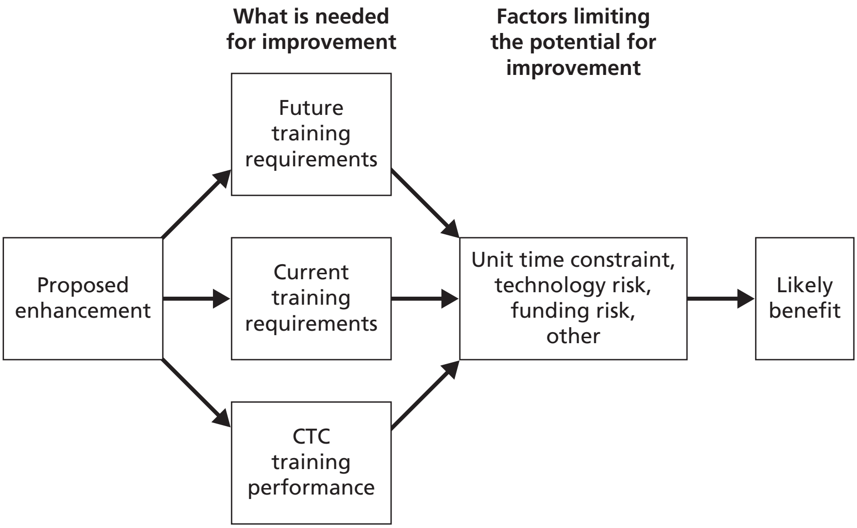
[1] These are training systems not under the FCS program but considered essential for meeting the training needs of the FCS BCTs. There are five: Simulation Environment Core (SE Core), One Semi Automated Force (OneSAF), Army Training Information Architecture (ATIA), One Tactical Engagement Simulation System (OneTESS), and Common Training Instrumentation Architecture (CTIA). See Memorandum "Essential Training Complementary Programs," Commander U.S. Army Armor Center and Fort Knox, dated January 2004.

Figure 4.1
Approach Used to Assess Individual Enhancements



RAND *MG538-4.1*

Next, we considered factors that might limit the enhancement's potential for achieving significant improvement.

The most frequently cited limiting factors for achieving significant improvement in the 2016 timeframe were constraints on unit time, technology risk, and funding risk. Each is more fully explained below.

Unit Time Constraint. As described in the previous chapter, the primary factor constraining unit training programs is time to plan, prepare, and conduct the training. If an enhancement makes additional demands on unit time, the potential benefits will be achieved only to the extent the unit's leadership is willing to replace a different activity.

Training Technology Risk. Technical risk involves the reasonable expectation that the desired enhancement capability will be technically achievable and fielded by the 2010–2016 timeframe. This aspect varies by enhancement and will be discussed in subsequent chapters of this report.

Funding Risk and Resource Shortages. Funding risk involves the reasonable expectation that the desired enhancement capability will be sufficiently funded to be realized by the 2010–2016 timeframe. In current budgets (i.e., FY06–11 Program Objective Memorandum, or POM), planned enhancements, even those validated by Army Headquarters, are not funded at the 100 percent level. Increasing (and, in some cases, even maintaining) funding resources for training modernization and other enablers will be difficult in the current programming environment. Currently, total resources for training are expected to remain fairly constant or to decline. As the Army moves forward, new funding will be sought by many programs that arguably have higher priority and involve more immediate and pressing needs than training modernization, including the current war, Base Realignment and Closure (BRAC), modularity, modernization, and restationing.

In many ways, the funding constraint is the key one, as it is often part of what explains the existence of the other two. For example, unit time is a constraint partly because of resource shortages for assisting units, and technology risks often derive from the fact that resources required to develop a new capability in the near term exceed the available funding.

This approach of comparing enhancements to training needs in the light of potential limiting factors resulted in our assessment of the key "likely benefits" of the enhancement. These benefits were specific to the 2016 timeframe (the expected date of fielding of the FCS infantry fighting vehicle and tank at the time of our study), and to the training of BCTs equipped with FCS technologies. Thus, the likely benefits are purposefully *not* the benefits listed in requirements documents, but our assessment of *what could reasonably be achieved by 2016 given the associated challenges and constraints on each enhancement*.

In addition to an assessment of the enhancement categories individually, we also assessed their value in aggregate, including how well they complement each other and achieve a cost-effective balance of investment. For this analysis, our approach was to first rate the benefits of each enhancement against three qualitative measures, or metrics, of training program improvement for BCTs equipped with FCS technology. These metrics are defined as follows:

- **Training quality**. The potential of the enhancement to increase the desired training effect, as determined by increased training event realism, complexity, and feedback.
- **Quantity of training events**. The potential of the enhancement to increase the number and duration of training events, as well as the number of soldiers or leaders trained. "Increases" in the quantity of training can be achieved either directly or indirectly. For example, quantity was considered to be favorably affected if the enhancement allows events to be run in a shorter amount of time (for preparation, execution, and after action review), if the enhancement increases the amount of time available for training (e.g., embedded training (ET) allowing more training while deployed), or if the enhancement decreases the need for training (e.g., greater unit personnel stability decreasing the need for sustainment training).[2]
- **Adaptability of training events**. The potential of the enhancement to support the adaptation of training events to a wide range of full-spectrum METT-TCs.

The qualitative categories we used for each metric to describe improvement for the enhancements were either "much," "some," or "minimal." An implied fourth possibility would be "none" for "no noteworthy improvement expected." Our assessments were intentionally conservative and intended to measure the extent to which the enhancement would help the Army reach a level of training capability in relation to requirements that was comparable to that achieved in 2001–2002, when the Army was concentrating on the need to face a largely major theater war/high-intensity conflict threat. Thus, our implied baseline standard is the extent to which the enhancements

[2] Actually, as can be seen, this is effectively a potential *reduction* in quantity of training *required*. The net effect in our quantity dimension is thus positive.

helped the Army to improve relative to training levels in the predeployment era.

It is important to note that these assessments were not meant to determine whether or not enhancements were worthy of future funding. We found that all enhancements have some value. We recognize, furthermore, that even if a particular enhancement in itself does not significantly improve the quality, quantity, or adaptability of training according to the standard defined above, it might nonetheless represent a necessary step in the direction of needed training program improvement. Moreover, even though a particular enhancement might not greatly benefit the training programs of BCTs equipped with FCS systems (our focus), it might still have an important effect in other training areas, such as for training above brigade level, or training for other parts of the force (e.g., CS and CSS units). We tried to note where these effects might occur.

In addition to comparing on a broad scale via the metrics, we also conducted more-focused comparative assessments of benefits, e.g., in the context of the training of battle command skills. Next, we examined the potential for assigning costs to enhancement categories, to enable the comparison of costs with benefits across categories and to provide a basis for making tradeoff decisions in a resource-constrained environment.

As a part of our analysis of the balance among enhancements, we also examined the adequacy of the Army's process for making tradeoffs among investments in training support. The Army's Training Support System (TSS) review process supports resource prioritization decisions within the Army's budget on TADSS, training products, training information infrastructure, training services, and training facilities and land. The lead for managing the execution of the TSS is the U.S. Army Training Support Center; oversight resides with Department of the Army (DA) G-3/-5/-7, which manages resources and the priorities for resources across systems. Inputs in the annual review process are received by TRADOC school leaders, user representatives of enhancements, program executive officers (PEOs) and program managers (PMs), other DA staff (i.e., from G-8), and training and combat developers. The reviews have four levels of management oversight, capped by a Training and Leader Development General Officer Steering Committee (GOSC).

In Chapters Five through Ten we summarize the likely benefits and limiting factors of the twelve enhancement categories, one at a time. In Chapter Eleven, we provide an integrated assessment across enhancement categories and the conclusions we draw from that analysis. Finally, in Chapter Twelve, we present our recommendations.

CHAPTER FIVE

Assessment of Planned Live Training System Enhancements

In this chapter, we focus on enhancements planned for live training. Live collective training has long been and remains the cornerstone of maneuver BCT training. Units conduct live training on training areas at and near their home stations, and at the maneuver Combat Training Centers.[1]

We discuss enhancements for live training at both home station and the CTCs. We begin by describing the Army's current capabilities for live training and the challenges it faces. We then discuss proposed enhancements, first for live training overall and then those specifically envisioned for CTC training, as well as the likely benefits and limiting factors in the 2016 timeframe. Finally, we draw some overall conclusions for each type of live training about the potential future effect of the proposed enhancements with regard to the quality of training, the number and duration of training events, and training system adaptability.

Current Live Training Capabilities and Challenges

Live Training Capabilities

There are two main types of live training: force on force (FOF), in which the unit being trained operates against a live enemy, and force

[1] Maneuver CTCs are training facilities large enough and with resources sufficient to conduct battalion- and brigade-level collective live (including live fire) tactical maneuver exercises. The Army has established three maneuver CTCs, two in the United States and one in Europe. One of the maneuver CTCs in the United States, the NTC, focuses on training heavy brigade combat teams, while the other, the Joint Readiness Training Center (JRTC), focuses on training light brigade combat teams.

on target (FOT), in which the unit being trained operates against a target array, generally using live fire. FOT also includes individual and crew weapons qualifications. FOF and FOT are complementary in that each involves some aspects of combat realism not present in the other. For example, FOF has an adapting enemy, while FOT involves the danger of using live ammunition and requires soldiers to fully exercise marksmanship and gunnery skills.

Technologies and Facilities. There are several key resources associated with live training designed to enhance its value. The nonmanpower resources include the following:

- **Tactical Engagement Simulation Systems (TESS).** These simulation systems replicate FOF signatures and casualty effects of actual weapon systems during FOT and FOF battles. They also collect engagement and training data from soldiers and system platforms.
- **Maneuver Areas.** These are areas over which units can conduct FOF collective training events. Current heavy BCT installations have close access to sufficient maneuver area to train at battalion or BCT level.
- **Ranges and MOUT facilities.** Ranges refer to the locations at which FOT training takes place. Current heavy BCT installations have a capacity to conduct live-fire training and qualification exercises from individual small arms through company- or battalion-level collective live fire, and the NTC has a capability to conduct BCT-level live-fire exercises. All BCT installations have a capability to conduct MOUT FOF exercises up to company level and FOT exercises up to squad or platoon level.
- **Targetry systems.** These systems include targets, battlefield effects and signatures, control of targets, and target engagement scoring systems, primarily for live fire.
- **Instrumentation systems.** These systems collect time, position, location, and engagement data during FOF and FOT from TESS and targetry systems, as well as from additional instrumentation on weapon systems and individuals. These data, in turn, support exercise development, control and execution, and after action review (AAR) preparation and conduct.

The capabilities of maneuver CTCs are supported by the Army's most capable instrumentation and training aids, devices, simulators, and simulations (TADSS). For example, the NTC has instrumentation to allow automated replication of artillery fires and chemical strikes. It also has aviation TESS, and a capability to "wrap" virtual UAVs and other non-BCT assets into the BCT's training events.[2] The instrumentation and tactical analysis facility allows the location, movement, and engagement data to be tracked for a majority of the BLUFOR[3] and OPFOR forces on the battlefield. These resources are not currently available for home station training.

Training Manpower. Live training must also be supported by training manpower that helps plan, prepare, conduct and evaluate training and training events. For live training at home station, installations have manpower resources that provide some help, but the majority of training is self-supported from within tactical units themselves. Those involved typically include the training audience itself plus the next two echelon organizations and other higher headquarters elements within the division. The current capabilities and challenges of this type of home station support are addressed in Chapter Nine.

Maneuver CTCs have been provided with extensive manpower resources to support their mission from other sources:

- **Operations Group.** Each CTC has a dedicated Operations Group. These groups are a combination of military personnel and DA and contract civilians who design the rotational training; control the exercise; role-play higher, adjacent, and supporting units; observe the unit and collect data throughout the course of the training; facilitate feedback during AARs; and provide unit take-home packages (documents outlining the training conducted and

2 Wrap-around means that virtual or constructive simulated friendly and enemy units and activities can be "wrapped" into the unit's actual digital command and control systems. Thus, to the training audience, the battlefield looks more complete than it would if it were replicated only by live personnel and equipment. This capability is discussed in Chapter Nine in the section on Live-Virtual-Constructive Integrated Architectures (LVC-IA).

3 "BLUFOR" refers to Blue Forces, that is, the organization being trained in a training exercise.

recommendations for skills to be sustained and improved during future training). As an example of the size of the staff needed to accomplish these functions, the Operations Group at the NTC is currently authorized 703 military and DA civilians.[4] In addition, there are almost 200 contractors to operate the NTC's instrumentation, support exercise control and data collection, support TESS sustainment, and otherwise support the Operations Group's mission.

- **OPFOR and other COE elements.** The CTCs have dedicated OPFOR and contracted role players. At the NTC, the core of OPFOR has been provided by the 11th Armored Cavalry Regiment, which includes a tank battalion, mechanized infantry battalion, aviation section, headquarters, and support squadron.[5] This core is normally augmented. For mid- to high-intensity rotations, an infantry battalion and one to two engineer companies normally support the OPFOR mission.

The maneuver CTCs have also gone through considerable recent change to meet current challenges. To replicate the COE, the OPFOR have adapted by learning to replicate an insurgent enemy. The CTCs have also expanded their capability to role-play civilians, NGOs, local government officials, and police, primarily through contracting civilian support. Also, the MOUT facilities at the CTCs have been greatly expanded, especially at the NTC.

Live Training Challenges

To allow soldiers to get the maximum benefit from live training, the Army has to address live training challenges in several areas, including creating realistic conditions for FOF and FOT training, having sufficient facilities and maneuver areas available in which to conduct train-

[4] Briefing by LTG Wallace, "CTC Way Ahead Implementation," 30 March 2005. The JRTC and CMTC have similar authorizations.

[5] The 11th Armored Cavalry Regiment deployed to OIF between 2005 and 2006. During its deployment, the OPFOR mission has been picked up by the Army National Guard and other nondeployed active and reserve units.

ing, and overcoming time and manpower constraints.[6] The COE and modernization present additional challenges.

Realism Challenges. Achieving realism adds difficulty and complexity to the setting up and supporting of effective live training events. Achieving realism depends on both the technical capabilities available for live training as well as manpower support elements. For example, one aspect of realism in live training is to replicate the signatures and casualty effects of actual weapon systems during battles. To achieve this in FOF training, the Army uses both a technological component (TESS) and a manpower component (OCs).

As explained above, TESS is the key TADSS (training aids, devices, simulators, and simulations) supporting FOF training. TESS is designed to provide combat-like effects on the FOF battlefield. The Army's current TESS system is supported by the Multiple Integrated Laser Engagement System (MILES).

MILES, based on 1980s technology, has at its core a laser-based system in which the shooting weapon sends a laser beam each time the individual or crew engages.[7] The individual or crew being engaged will hear one signal if there is a hit and another for a near miss. For vehicles, there is a "kill code" display showing the type of weapon system that caused the kill. There are several fielded versions of MILES technology (e.g., MILES XXI), the later models being lighter, more reliable, and

[6] In related RAND research, we have seen that current forces (given deployments and changed operational missions) have had difficulties in achieving the frequency of live training outlined in the Army's Combined Arms Training Strategies and also in achieving a high level of training realism at home stations. The fact that units, at the time this report is being written, are requesting lanes training at the CTCs reinforces the need to improve the frequency and realism of live training at home station.

[7] While the basic MILES technology is laser-based, there are many other components to the system. The lasers work only for direct fire kills and are limited to line-of-sight direct fire engagements, so supplementation is necessary to replicate other weapon systems. For example, if mortar fire is successfully called on a target, a controller or "fire marker" moves to the engaged system or individual and manually "shoots" the target with a MILES controller "gun." In addition, each individual carries a card which shows the soldier, if hit, whether he is "killed" or "wounded"; for wounded soldiers, the card shows the type of wound (to allow the casualty care and evacuation system to be exercised).

showing more information to engaging crews.[8] The current MILES system has proved effective but has significant limitations in the extent to which it can achieve realistic replication of all weapon systems, especially for engagements in close terrain.[9] Additionally, the expanded array of far more capable lethal and nonlethal effects at the disposal of the FCS-equipped BCTs during operations will greatly increase the challenge of replicating its capabilities. Some of the key challenges are summarized in Table 5.1.

Table 5.1
Limitations to MILES

The laser will not penetrate smoke or vegetation, thus offering protection where this would not be the case for actual projectiles.
Firing cues are unrealistic (e.g., firing signatures are far quieter and less visible than for actual weapons firing, thus making acquisition more difficult).
There are no visual round tracers or impact signatures, thus lowering the probability of hit for many weapon systems. For example, with tracers, a machine gunner can “walk” rounds into the target, but not so with MILES.
MILES cannot replicate many weapon systems at all, including mines, artillery and mortars, IED, Claymore, hand grenades, and nonlethal systems. These must therefore be adjudicated by OCs or fire markers, creating a burdensome support requirement. [a]
These factors mean that the suppressive effects of many weapons are far less in training than would be the case on an actual battlefield.
For very close engagements the shooter must aim at sensors rather than at center of mass.
Crews and gunners cannot use proper live-fire methods (e.g., lead the target).
Weapon boresight and zero can be easier to lose for some weapon systems.

[a] Some NLOS/area fires/mines/NBC effects are automated at CTCs through their instrumentation systems, but the Army has not been able to afford such systems for home station training.

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[8] To provide a capability to support tank and BFV gunnery training, the Army has also developed and fielded live gunnery simulations systems, Tank Weapons Gunnery Simulations System/Precision Gunnery Simulations System (TWGSS/PGSS). These systems support FOT but not FOF training.

[9] MILES has other limitations as well. MILES for aviation is not available for home station. Preparation for MILES training is time-consuming (requiring installation of the system, bore-sighting, preoperational checks, etc.). MILES must be logistically supported (spare parts, maintenance, batteries, etc.), and the support facilities are not normally open around the clock.

To account for its technical limitations and to provide training feedback during the AAR process, MILES requires a relatively sophisticated training support system. Achieving such a system is particularly difficult, especially for home station training. The requirements can be extensive for higher-echelon exercises and for exercising a full range of the battlefield operating systems (e.g., providing a fire marker system for indirect fires). Key to collective FOF and FOT training are observer/controllers (OCs), trainers enforcing rules of engagement (ROE), including those necessary to overcome MILES technology limitations and to ensure proper tactical movement and positioning during live-fire exercises. OCs also observe the training to provide the "what happened" and to facilitate learning during the AAR process.[10]

Challenges Related to Maneuver Areas, Ranges, and MOUT Facilities. Another constraint upon live training is increased competition for maneuver area, ranges, and MOUT facilities. The restationing of units back from Europe and Korea, as well as modular BCT organization which adds brigade-sized maneuver elements (33 to 43 or more AC maneuver BCTs), means that more units are competing for the same maneuver and range areas.

The Army is also limited in its ability to add to its amount of maneuver and range area, let alone to fully use the areas it has. There are also environmental constraints to the full use of range and maneuver areas for training. Portions of training areas have been contaminated by unexploded ordnance, and clearing these areas to allow maneuver is costly. Increasing civilians and military demands also constrain the frequency spectrum available for operational and training use of maneuver and range areas. For example, while it is increasingly important to integrate joint, Army aviation, and UAV into small-unit training events, air space is constrained, and the increasing number of aerial platforms limits the ability to achieve realism in this regard.

[10] For example, an aspect of ROE would be adjudication of close range engagements where a shooter engages a target at very close range but the laser beam does not hit the sensor on the target, even though the shooter would obviously have hit the target. In such a case the OC would determine the engagement successful and assess the target as a casualty.

While the CTCs have extensive range and maneuver areas, as well as MOUT training sites, these centers are facing a challenge due to demand for an increased throughput capacity. The emerging ARFORGEN strategy calls for two CTC or CTC-equivalent training events for each AC BCT over a three-year cycle. The increase in AC BCTs from 33 to 43, and the current goal of one CTC per BCT every two years, places an increased throughput requirement on the CTCs.

Additionally, there will be an increased requirement to provide CTC-equivalent training for the BCTs in the Army National Guard (ARNG). Under the current strategy, each of the ARNG's 15 Enhanced Separate Brigades received a CTC rotation or an equivalent event every six years. The frequency of maneuver CTC training for ARNG BCTs is still being deliberated, but the current concept is for each of the 34 ARNG combat BCTs to undergo a CTC rotation every six years. This would essentially double the demand for CTC rotations from this source. At a minimum, an ARNG BCT will receive a CTC mission rehearsal exercise prior to deployment.[11]

Challenges Regarding Time and Manpower Resources. Constraints on time and manpower also affect live training. At the home station, the key constraint is the time needed for unit leaders to plan, prepare, support and conduct live training. This constraint significantly limits the quality, quantity, and adaptability of training at those locations. While this constraint has existed for a long time, it is increasing, as the COE, modernization, and operational deployments add to the training requirement and the demands on unit time.

For training at the CTCs, a comparable challenge exists in regard to dedicated training manpower support. Although requirements are increasing, resources are holding constant or decreasing. As one example, consider the effect of deployments on training resources. For the Operations Groups, there is an increased and likely enduring requirement to prepare BCTs for operational deployments by conducting mission rehearsal exercises. At the same time, there appears little likelihood that the Operations Group will increase in size; in fact, given the current objective of establishing a CONUS (Continental United

[11] Briefing by LTG Wallace, "CTC Way Ahead Implementation," 30 March 2005.

States) exportable training capability (ETC), and doing so with no net changes in manpower resources, reductions are already planned in Operations Group manpower available at the CTCs themselves. The result will be either that units continue to have responsibility for augmenting the role of the Operations Groups at the CTCs (complicating their own training plans), or that units accept degraded training quality during their rotations. For the OPFOR at the CTC, current operational requirements have driven the Army to use these units in an operational role; as a result, the Army has recently had to rely entirely on ARNG and borrowed AC units to perform the OPFOR mission. Some of these units may be less experienced and capable than the dedicated OPFOR they are replacing; moreover, this use of an OPFOR with less experience comes at a time when the job is expanding and becoming more complex.

Challenges Related to COE and Modernization. Additional challenges for live training are arising due to the COE. Live training is already in the process of changing and faces the need for continuing transition. Future enemies are likely to try to fight throughout our battle area using ambushes, surprise attacks against support organizations and facilities, and other asymmetrical types of operations as the preferred tactical methods. Operational success will therefore depend on the success of squads, platoons, and companies, which, in turn, depends on the tactical and live-fire proficiency of these small units and the adaptability of their leaders to deal with the wide range of COE conditions. These changes make conduct of effective live training different and, in most ways, especially difficult at home station.

Some of the challenges associated with the COE include the following:

- Asymmetric enemy methods give rise to a need for all units to have greater training on self-defense tasks, thus increasing the need for more time and maneuver/range areas to be devoted to FOF and FOT training by combat support and combat service support units.

- The asymmetric battlefield also increases the need for training to prepare for a 360-degree battlefield. This creates complications for units needing to set up live-fire exercise battle courses.
- COE adds to OPFOR and role player support and training requirements. This complicates FOF and especially live-fire exercise requirements. Live FOF is no longer a matter of having two units operate against each other using only slight variations in their normal tactics and techniques. Instead, OPFOR must be trained and equipped to replicate unconventional as well as regular enemy combatants. There is also a need to include noncombatants in training events, which adds to preparation and training of these elements. More complex targetry is required on FOT ranges to exercise fratricide and collateral (noncombatant) damage prevention.
- MOUT has become a more likely operational environment, making an adequate number of FOF and FOT MOUT training facilities an increasing need. Moreover, the wide range of possible types and sizes of urban terrain means that providing a full capability is impractical at any single post. Finally, the funding levels and time needed to plan, program, and construct these facilities mean that providing for this need will be a long-term process.
- The increased use of joint and combined arms combat multipliers makes replicating and assessing battle results more complex.
- Likewise, the OPFOR must include more combat multipliers, for example, using improvised explosive devices (IEDs).

The COE increases the need for role players in order to maintain training effectiveness, in this case, for civilians, local government representatives, coalition police, and military, nongovernmental organizations (NGOs), Special Operations Forces (SOF), and governmental personnel.[12] To take a concrete example, the emphasis on constructing MOUT facilities generates a need to "man" these so that they resem-

[12] The JRTC has featured complications like these for years, so the capability to do so is established and well understood. The issues are scope, time, and resources.

ble urban environments. These role players must be well trained and rehearsed to be effective.

Modernization has also made the function of conducting a fully realistic training event and providing training feedback more complex. For example, while digitization increases the ability of units to share information, C2, and a common operating picture, it makes it more difficult for trainers to "eavesdrop" on their units to understand the degree to which the training audience was operationally aware, and to track the orders and reports received and transmitted. This makes the task of facilitating an AAR more complex. Modularity has also added to the number and type of organizations that need to be trained.

Modernization (C4ISR) and modularization have enlarged the battle area, even for small elements (e.g., companies and even platoons can detect and engage enemy "over the hill" with indirect lethal and nonlethal effects). As a result, the size of home station ranges and maneuver areas is becoming less adequate. The capabilities and concepts for the FCS-equipped BCT require even greater maneuver and live-fire training areas than current BCTs. For example, the radius for the area of influence of an FCS-equipped BCT is 75 kilometers, far greater than that of today's BCTs, and larger than the current maneuver areas of all active Army installations including the NTC, JRTC, and Fort Bliss.[13] In fact, even doctrinally sized battalion maneuver areas for FCS-equipped combined arms maneuver battalions will be beyond the capacities of many installations.

The COE and modernization have also complicated live-fire training. While most installations have a reasonably complete set of live-fire training capabilities, these requirements are increasing and will further increase for FCS-equipped BCTs. The COE and likelihood of enemy asymmetrical tactics has added to the need for tactical live-fire ranges where the unit can engage targets in multiple directions and generates a need for more-complex scenarios and targetry. Also, such training is needed by support as well as combat units, and this generates a larger

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[13] The area of influence is "the geographic area wherein a commander is directly capable of influencing operations by maneuver or fire support systems normally under the commander's command or control."

throughput requirement. The expanded areas of operations and noncontiguous nature of FCS-equipped BCT concepts, coupled with the increased range capacities of FCS weapon systems, mean that the areas required for realistic live-fire ranges have substantially expanded. Yet, again, there is little ability to add training land, especially for live fire.

Proposed Live Training Enhancements

The Army has already taken steps to address the need to improve live training, particularly in the area of improving realism and adjusting training to the needs of the COE. The Live Training Transformation (LT2) initiative was conceived in 2001 to bring all live training technology enhancements under a single program. The LT2 initiative uses a component-based, product line architecture to bring together future live training systems.[14] Overall, the intent of LT2 is to make training systems more effective and efficient by:

- Supporting full-spectrum FOF and FOT training.
- Improving exercise planning by linking it with other Army training planning tools.
- Providing a better means to monitor and control training exercises.
- Providing better communications between LT2 subsystems, virtual and constructive simulations, and operational C4ISR systems.
- Improving the means of recording, adjudicating, and enforcing lethal and nonlethal engagements.
- Providing a better means to manage, collect, visualize, and analyze unit and individual performance data.
- Supporting better development and presentation of AARs and other training feedback products for the unit to use.

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14 A key component of the LT2 initiative is the Common Training Instrumented Architecture (CTIA). CTIA is the baseline architecture for all LT2 systems' software, hardware, and data. For a full explanation of these and other architectures, see the previous section.

Eventually, the LT2 initiative will be consolidated into three live training requirements documents, one for the CTCs, one for home station/deployed units, and one for the common live training components.

In this section we discuss some of the key enhancements planned for improving live training.[15]

Proposed Enhancements, Likely Benefits, and Limiting Factors

We focus on specific enhancements in four areas: TESS, targetry, ranges/MOUT facilities, and instrumentation systems.

TESS. OneTESS is designed to address some of the limitations associated with the need for realism in live training. While MILES has revolutionized training and is still improving, it has significant limitations, which present challenges to achieving fully realistic live training conditions.

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[15] For our discussion in this chapter, we drew upon a range of existing documents. We have examined a wide set of requirements documents, briefings, and other documentation describing this program and its key elements. These include "Initial Capabilities Document (ICD) for Live Training Transformation–Family of Training Systems (LT2-FTS)," dated 22 February 2005, U.S. Army Training Support Center, Fort Eustis, VA; "Operational Requirements Document (ORD) for the One Tactical Engagement Simulation System (OneTESS)," dated December 2004, U.S. Army Training Support Center, Fort Eustis VA; "Operational Requirements Document for the National Training Center–Instrumentation System (NTC-IS)," dated 15 June 2005, U.S. Army Training Support Center, Fort Eustis, VA; "Operational Requirements Document (ORD) for the Home Station Training System (HITS)," dated 14 June 2004, U.S. Army Training Support Center, Fort Eustis, VA; "Operational Requirements Document for the Integrated Military Operations on Urban Terrain (MOUT) Training System (IMTS)," dated 13 March 2002, U.S. Army Training Support Center, Fort Eustis, VA; "Performance Specifications for the Digital Range Training Systems (DRTS)," dated 1 November 2004, U.S. Army PEO, STRI, Orlando, FL; "Operational Requirements Document for the New Generation Army Target System (NGATS)," dated 4 June 1996, U.S. Army Training Support Center, Fort Eustis, VA; "Army/Joint–Future Force Ranges White Paper," Coordinating Draft, dated June 2005, ATSC, Fort Eustis, VA; "Statement and Objectives for Live Training Transformation (LTT)/Common Training Instrumentation Architecture (CTIA) Product Line Development Task Order," undated; and "Army Training Information Architecture–Migrated Initial Operating Capabilities (ATIA-M-IOC)" document 3.4, 2005, U.S. Army Training Support Center, Fort Eustis, VA. Additionally, we have engaged in extensive dialogue with training and material developers at the Army's Army Training Support Center at Fort Eustis, the Combat Center Directorate at Fort Leavenworth, and PEO STRI at Orlando.

Benefits. OneTESS is more than a MILES upgrade program, as it has requirements to incorporate emerging technology to overcome the training capability limitations of laser-based systems, with the objective of more fully replicating lethal and nonlethal weapons effects in FOF and FOT training.[16] These effects include nuclear, biological, chemical (NBC), directed energy, fire and forget, NLOS/BLOS, electronic warfare, mines and countermines, and close air support (CAS). OneTESS goals include allowing the Army to better replicate the full array of dismounted weapons, including hand grenades and claymores and future force weapon systems. Unlike MILES, OneTESS requires gunners to use proper engagement techniques (e.g., lead) so it will also support FOT training as currently accomplished by the Tank Weapons Gunnery Simulations System (TWGSS)/Precision Gunnery Simulations System (PGSS). OneTESS will also adjust protection levels for soldiers and systems that are properly "dug in" or otherwise protected.

The system also has a goal of better supporting training in urban operations and other close terrain. It is to simulate the appropriate effects on personnel inside or near structures and vehicles, to include suppression. Soldiers will be able to employ their weapon systems and produce casualties by projectile penetration of the buildings. Thus, it is designed to reinforce marksmanship in a close environment, while eliminating dysfunctional training that occurs when soldiers conceal themselves from laser-based TESS. Another objective is to provide precision gunnery capabilities with AAR feedback to better support marksmanship and gunnery skills. OneTESS is also required to provide more realistic weapon cues.

As a Common Training Instrumentation Architecture (CTIA)-compliant system, OneTESS also aims to better support exercise planning and scenario development. It will support rapid assignment of identification (e.g., force, unit assignment, names) and automated identification of players. In addition, it aims to better support control, safety, and data collection functions during live-fire training exercises.

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[16] OneTESS has embraced the concept of spirally leveraging wireless, geometric pairing, RF communications, and other emerging technologies to facilitate NLOS and other types of engagements that are difficult to replicate with laser-based technologies alone.

Automatic collection of shooter and victim data can improve the quality of AARs and can automate the need for many controllers, thus reducing some of the training support requirement, but even with these improvements, the number of trainers required for FOF training will remain unchanged. However, trainers should be able to concentrate on their trainer duties and quality should increase.

Limitations. OneTESS is currently in the research and development phase and, as such, carries with it some technological risk. As with any program in this phase, the degree to which the requirements will be affordably achieved to reach all threshold and objective capabilities is unclear, but it will almost certainly be less than the full set of requirements. Of special concern in terms of technology is the system's ability to fully overcome laser issues, including lack of realistic cues and signatures. Achieving affordable solutions for individual weapon systems is likely at a far higher level of risk than for crew-served weapons such as tanks and BFVs. Overall, our assessment is that the full set of requirements will not be achieved until sometime past 2016.

Fielding schedules will also limit the force-wide improvements of OneTESS, particularly for home station. Current projections show a threshold OneTESS system set to begin fielding in 2010, but initially only to the CTCs. Moreover, the threshold system will be applied only to major weapon systems, and will not include individual weapon system replication. The current goal is to begin fielding the full objective system around 2015. Thus, most home stations will not have the full system until well after 2016.[17]

Targetry. The Army has proposed several enhancements designed to improve FOT training.

Benefits. The key future enhancement in the area of targetry is the New Generation Army Target System (NGATS).[18] There is also a

[17] The development of a live training capability does not mean universal availability. Procurement of live TADSS is normally spread out over long periods of time, often up to 10 years. Thus, there will be "have" and "have-not" installations.

[18] Recently the NGATS program was restructured into a new program called Future Army System of Targets (FAST). At the time this document is being written, the specifics of this program were being developed but appear to be basically the same as those of the NGATS program.

separate enhancement, Battlefield Effects Simulator (BES), which will also provide better engagement cues and signatures. NGATS is geared to replace obsolete, expensive, and lower-quality targetry with more COE-realistic targets that have better weapon signatures and effects. The system includes requirements for more realistic friendly, neutral, and threat targets, threat weapon engagement cues, and weapon effects on target simulation. NGATS will support live-fire exercises for individual and crew-served weapon skill qualification and sustainment, as well as other FOT collective training events at local training areas, CTCs, and in tactical force projection environments. In these areas, it will also collect data on TESS as well as live round engagements. In support of NGATS, capabilities to conduct live fire and improved automated engagement feedback will be introduced on many of the improved weapon systems for the FCS-equipped BCT.

Limitations. The funding and timing and fielding of future targetry are at risk, at least with regard to fielding by the 2010–2016 timeframe. The program was in the research and development phase, but a recent DA-level budget decision cut the program's funding, and a decision has been made to completely restructure the program. There will also probably be technical risk in providing sufficiently realistic weapon signatures and cues to discriminate between various types of weapon systems of the same category (e.g., between different calibers of small arms).

Live Ranges/MOUT Facilities. The Army is also designing a series of training facilities, ranges, and range complexes to supplement current live capabilities to meet the extended FCS and COE live training requirements.

Benefits. These enhancements are likely to result in an improved capability to train COE-related tasks and to provide for an improved quality of weapon effects. Especially noteworthy is the addition of improved and standardized dismounted and combined arms, MOUT, and convoy live-fire ranges and facilities. Techniques are being developed to include at least a 180-degree live engagement capability on some collective ranges. Also included are "shoot houses," which allow individual-, squad-, and platoon-level live-fire training on key tasks, including tactical movement, engagement of targets, practice at target discrimination, and the conduct of breaching in a building.

New range facilities will decrease the need for units to design and lay out live-fire exercise areas "from scratch." Ranges are being developed to support FCS-equipped BCT increment 1 weapon systems capabilities, including NLOS and BLOS. Some of the specific facilities and ranges being developed include:

- **Close Combat Qualification Complex (CCQC).** This is a facility of approximately 54 square kilometers, supporting dismounted individual and crew weapons training and qualification (including dismounted NLOS). It has a live pyrotechnic, demolition, and grenade training capability, with an option for including an engineer assault course. Additionally, it has a convoy live fire, and an urban assault weapons course.
- **Line of Sight (LOS) Crew/Dismounted Infantry Qualification Range (LC/DIQR).** This range will provide for training of small mobile hunter-killer teams of individual tanks, infantry combat vehicles (ICVs), helicopters, and infantry squads on live-fire cooperative engagements. It will be approximately 4 square kilometers in size but be configured for 180- to 360-degree engagements.
- **Mounted Urban Gunnery Range (MUGS).** This is a 20-square-kilometer range that provides for live-fire training of individual ICVs, tanks, and dismounted infantry under complex urban training conditions.
- **FCS Collective Training Range (FCSCTR).** This is a 48-square-kilometer range that supports free maneuver live fire or FOF tactical operations. The range will support collective applications of all aspects of the FCS-equipped BCT's operational capabilities. It includes shoot houses and live-fire villages.
- **Combined Arms Live-Fire Exercise (CALFEX) complex.** This large (125-by-75-kilometer) complex supports company and battalion combined arms live fire (sub-caliber) and TESS training incorporating the full range of FCS-equipped BCT and joint capabilities.

- **FCS Crew Weapon Systems Qualification/Training ranges.** These include specially configured ranges for armed robotic vehicle (ARV), NLOS, and UAV crews.
- **MOUT facilities.** The Army has placed a priority on improving the number and quality of MOUT FOF and FOT training facilities. Several versions of prefabricated-type facilities have been developed and fielded. There are also joint initiatives to develop four additional battalion-level MOUT training facilities capable of supporting joint training objectives.

The addition of these facilities should reduce the preparation time needed for training events and may also reduce support requirements.

Limitations. While funding currently exists for new ranges and live training facilities, their success within the timeframe of this analysis will depend on the degree to which all the requirements can be made affordable. Construction can be especially costly for such products (especially for realistic MOUT sites), and fielding has been traditionally slow. In the area of support, the usefulness of ranges and facilities will also depend on timely procurement of sufficient ammunition capability, which is likely to be a difficult task. Effective short-range training ammunition in particular will be a key need.

The ability of these enhancements to increase the amount of live training will be limited by the time the units can reasonably devote to live training, which is already at relatively high levels considering the total demands on unit time. Thus, the addition of these enhancements could provide an increased number of collective live-fire and MOUT training events, but it will probably not add to the total amount of live training being conducted.

Instrumentation. Instrumentation enhancements are largely improvements to data collection and analysis systems. These are key elements to the LT2 family of live training systems because they incorporate and link all the other LT2 component systems into a fully functional, integrated live training system. All instrumentation systems will be developed using common components from the CTIA and LT2 repository, thus ensuring common plug-and-play interfaces, graphical user interfaces (GUIs), and exercise control/AAR tools. The

Army's planned instrumentation enhancements include the Home Station Instrumentation System (HITS), the Integrated Military Operations in Urban Area Training System (IMTS), and the Digital Training Range System (DRTS).[19]

Benefits. Taken together, these instrumentation systems have the potential to enhance the feedback from training exercises and reduce the data collection workload of OCs.

HITS is an instrumentation system being developed to support exercise planning (along with other LT2 components), system preparation, exercise management, and training performance feedback at home station. This system will collect and collate the shooter, victim, position, movement and other data from TESS, targetry, and other simulation systems during FOF and FOT training. To widely support effective training event AARs, HITS will provide data and analysis at the home station maneuver training facilities, MOUT facilities, live-fire range complexes, and deployed sites. HITS is being developed to provide a scalable version of the maneuver CTC instrumentation system that would support units during a maneuver CTC training experience.

IMTS is an instrumentation system being developed to support FOF/FOT training in an urban environment. It is targeted for home stations and also the maneuver CTCs. The IMTS will be an automated data collection and analysis system that assists at all phases of a training exercise. It will support the control of the exercise, the simulation of battlefield effects, and the provision of training performance feedback to units. It will also support exercise planning and preparation, as well as scenario-development activities. The IMTS will consist of an integrated system of computer software and hardware; workstations; databases; recording, production, and presentation equipment; interface devices; and communication equipment. Within the urban operation training facilities, IMTS will collect and analyze exercise data from TESS, targetry, other system and nonsystem TADSS, OCs, and other

[19] Additionally, a set of highly capable instrumentation systems is being developed for the CTCs, but these will be considered separately in the next section along with other CTC enhancements.

external simulation and stimulation (SIM/STIM) systems. It will also collect, manage, and analyze voice, video, and digital training performance data.

DRTS will be designed to provide supplemental instrumentation capabilities needed to plan, prepare, execute, and provide training feedback during training on live-fire ranges. Special instrumentation aspects of live-fire exercises are target control and presentation (to support the training scenario), and collection and presentation of target engagement results.

These instrumentation enhancements can improve the ability of units to conduct more-complex live training events, as well as to reduce some of the data collection requirements of today's OCs. DRTS also provides the potential to better analyze and present performance data to the training audience during the AAR process and in-exercise Take-Home Packages (THP). Finally, DRTS increases the potential to use the results of training events to develop "lessons learned" that can, in turn, improve future unit performance, future training events, and Army-wide doctrine and training development.

Limitations. We conclude that it is unlikely that the Army will achieve all the benefits of these enhancements in the 2016 timeframe. These systems are not fully funded in POM 06–11. While there seems to be limited technical risk in achieving the capability to record and communicate position and engagement data in FOT and FOF training events in the 2010 timeframe, there may be affordability issues for achieving this capability for dismounted soldiers and some weapons system, as well as for larger-scale exercises across all installations. A more fundamental issue is the ability of unit trainers to effectively analyze the data generated. For example, at today's CTCs, many of the desired capabilities made possible by instrumentation have not been achieved. Even with a large dedicated training cadre, much of the potential instrumentation capacity at the CTCs goes unused because of the difficulty and workload associated with going through and making sense of the large amounts of data the systems provide. Making the data from instrumentation systems useful and easily accessible also requires the development of effective translation tools. Based on the limitations of the similar efforts to develop training tools for CTCs, and for constructive and virtual simulations and integrated LVC (discussed in subsequent chapters), we conclude that the new systems present a technical and training development challenge that has not yet been met.

Conclusions: Live Training Enhancements

Our assessments are summarized in Table 5.2.

The enhancements will provide some improvement to the quality of training. OneTESS and MILES improvements together offer some ability to improve the quality of training within the time period of this analysis, and some ability to reduce support requirements. Our review of the substance of the targetry enhancements shows that, to the degree these are attained and fielded, they will go a long way toward

Table 5.2
Live Training Enhancements: Likely Benefits and Limiting Factors

Enhanced Capability	Likely Benefits of Enhancement	Limiting Factors
TESS, e.g., MILES, OneTESS	• More weapon systems covered • Improved engagement feedback • Improved reliability	• Not fully funded (POM 06–11) • Fielding of OneTESS will occur after 2015 • Technical risk (full dismount, nonlethal, shoot through) before 2016
Targetry, e.g., NGATS, BES	• More COE realistic targets • Better weapon signatures/ effects	• Not fully funded (POM 06–11) • Fielding likely too slow to achieve many benefits force-wide by 2016
Live ranges/ facilities	• Reduced preparation time • Achieve better COE capability • Provide for improved quality of weapon effects	• Range area availability • MOUT sites costly • Ammo capability and costs a challenge • Fielding likely too slow to achieve many benefits force-wide by 2016
Instrumentation, e.g., HITS, IMTS, DRTS	• Reduces OC workload • Enhances feedback	• Training design risk • Requires concurrent development of effective tools • Not fully funded (POM 06–11)

improving the ability to provide more realistic live-fire exercises to train COE and MOUT tasks. The need for these types of improvements was strongly voiced during our unit visits. Our review of the substance of range and facility enhancements shows that they will result in an improved capability to train COE-related tasks, and will provide for an improved quality of weapon effects. Moreover, to the degree that new range facilities decrease the need to design and lay out live-fire exercise areas "from scratch," these facilities will reduce the preparation time for training events. Likewise, support requirements may be somewhat reduced as a result. Range and facility improvements also have some potential to improve the quality of training, as well as the flexibility of the training system (since the facilities will provide for a wider range of COE environments). Instrumentation system enhancements also show some ability to improve the quality of training within the time period of this analysis, and some ability to reduce support requirements. The major reservation in these areas is the degree to which the funding and fielding schedules can be obtained within the time period of our analysis.

The enhancements are unlikely to improve the quantity of live training. Our assessment found that enhancements generate no real increase in the frequency of live training events. Theoretically, range facilities also have a potential to increase the quantity of training conducted because, as stated above, they will decrease the need to design and lay out live-fire areas from scratch. However, we believe the potential benefits in this area will consist primarily of additional time for leader and soldier training rather than an increase in the number of live events conducted.

The enhancements can improve adaptability to some extent. Many of the targetry, range, and MOUT facility enhancements will generate an improved capability to train COE tasks and conditions. In particular, the success of the OneTESS program will be key to supporting the future live training capability, as the ability to replicate elements such as UAVs, nonlethal effects, and small-arms engagements is increasing in importance. OneTESS, improved targetry, and increased MOUT facilities will be important to improved COE live training capabilities.

That the enhancements will not completely close the gap with the new requirements in the 2010 to 2016 timeframe is due to a number of factors, some of which would be easier to address than others. First, achieving all the intended advances at all installations will, by technical and practical necessity (e.g., due to fielding plans), have to wait until after 2016. Further, the increases in training quality that are possible will be diminished by funding and, to a lesser extent, technical risks of the new technologies (see Table 5.2). Most of the systems are in research and development phases, and the degree to which affordable capabilities can meet the stated requirements is almost certainly less than the stated goals of these systems.

Achieving the benefits that could well be within reach can be compromised by traditional training challenges and constraints that will likely become more severe. For example, land area constraints, especially when considered in light of greater unit areas of operation and weapon system ranges and the expanded number of BCTs, will limit the ability to conduct realistic live FOF and FOT exercises at battalion level and above at most home stations. MOUT training will be a special concern, as only a limited range of urban terrain will be available at any one installation. Moreover, achievable improvements will be limited by the availability of unit time to support training. Even with the benefit of the new live technologies, the added training requirements mean that training preparation, execution, and evaluation will become more complex, and the need for trainers, OPFOR, and role players will remain and probably increase. The likely result will make unit time an even greater training constraint than it is today.[20]

CTC-Specific Enhancements

The CTCs provide BCT organizations with an opportunity to exercise a full range of BOS functions under realistic and demanding condi-

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[20] Other enhancements, beyond the live technologies reviewed in this section, will address the constraint of unit time in live training. For example, see the review of LVC integration in Chapter Six, and the assessment of training manpower support in Chapter Seven.

tions approaching combat to an extent not possible at home station. The benefit of providing this type of training opportunity was supported by our review of heavy unit training performance at the NTC, as described in Chapter Three.

This section reviews the enhancements planned specifically for the CTCs. While our comments consider all the maneuver CTCs, the focus will be on NTC enhancements, which are more relevant to the training of the FCS-equipped BCT.

Proposed CTC Enhancements, Likely Benefits, and Limiting Factors

A CTC modernization program has been developed and is being implemented to continue to improve the maneuver CTCs' capability to perform their increasingly difficult role in the Army's training strategy. The program components generally include and exceed those planned for home station either because the CTCs will benefit from the same enhancements sooner or because their enhancements will be more advanced.

Benefits. Key enhancements for CTCs include:

- **Maneuver areas and MOUT facilities.** The CTCs will likely undergo land expansion and obtain improved MOUT facilities to allow BCTs to train in doctrinally sized areas of operation (AOs) and to provide for the COE.
- **Instrumentation.** The CTCs' instrumentation system is being upgraded (and new Tactical Analysis Facilities built) so that the CTCs will have a far more capable and secure instrumentation system than the HITS described in the home station section. The Objective Instrumentation System will ultimately track all the BLUFOR and OPFOR individuals, role players, and weapon systems involved in the training. Automated AARs will be available down to platoon level. Field trainers will have an ability to monitor instrumented exercise participants' movement and engagement activities. In addition, the CTCs will receive the ABCS systems they need to monitor all BLUFOR unit digital nets.
- **COE adaptation.** The CTCs' OPFOR equipment is being upgraded to include tanks, infantry fighting vehicles, wheeled

> vehicles, anti-tank, air defense systems, and helicopters that better replicate current and threat equipment. Realistic IEDs as well as countermeasures are being fielded. A system for providing funds to hire and train civilian and other role players is also now in place.

These enhancements are clearly important to maintaining the maneuver CTCs' capability.

Limitations. The limitations of some of these enhancements have already been described in our assessment of home station live enhancements. For example, the CTC modernization program received low funding in POM 06–11, as measured by the percentage of critical defined requirements that received resources. In addition, the likely expansion in maneuver areas at the CTCs will likely not be commensurate with the increased space needed to fully train BCTs, thus complicating the training.

An additional limiting factor for CTC enhancements is that current planned enhancements do not include CTC manpower enhancements, and there is a good argument to be made that future training requirements warrant an increased manpower allocation for trainers, OPFOR, and role players. For example, the BCTs and FCS-equipped BCTs are far more complex organizations than their predecessors, and they will have division-level functions, equipment, and organizations. The COE generates a need to have more trainers to observe and control dispersed operations, such as MOUT clearance of a building.[21] In fact, the initiative to create an Exportable Training Capability (ETC) to increase the overall frequency of CTC-like training events (discussed in Chapter Nine) is envisioned to form this capacity using current maneuver CTC manpower, thus likely reducing the number of trainers at the CTCs.

In addition, it is likely that the OPFOR at the CTCs in the future will both be larger and have dual roles. While previously the NTC OPFOR portrayed a mid- to high-intensity mechanized threat, and

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[21] The needs were outlined in the briefings of the three maneuver CTC Commanders at the CTC Commanders Conference in September 2004.

the JRTC mainly a low-intensity threat, both CTCs will be required to portray a wider range of threat capabilities. Moreover, likely future threats will be more infantry-based, thus increasing the need for OPFOR manpower.

The need for role players is also likely to increase the need to represent noncombatants and interagency (e.g., CIA), and nongovernmental personnel. These role players must be well trained and rehearsed to be effective.

Conclusions: CTC-Specific Enhancements

Our assessment of CTC enhancements is shown in Table 5.3.

CTC live training will remain a key component of the training strategies of BCTs equipped with FCS technologies. In fact, the role of the CTCs will likely increase. FCS BCT operational concepts and capabilities will make the execution of realistic live FOF exercises at

Table 5.3
Maneuver CTC Modernization: Likely Benefits and Limiting Factors

Enhanced Capability	Likely Benefits of Enhancement	Limiting Factors
Maneuver areas and MOUT facilities	• Relatively extensive maneuver and live-fire areas • Some land expansion likely • Increased MOUT capability	• Increased BCT battlespace needs will exceed new areas
Instrumentation, including CTC Objective Instrumentation System (OIS)	• Capability to track battle—increased by OIS • Enhanced effects • Enhanced feedback	• Digitized units harder to eavesdrop • Low funding of critical needs as defined by DA G-3
Operations Group	• Capability not programmed for enhancement	• Planned reductions to support ETC • COE and modularity increase complexity
OPFOR, and role/real players	• Capability programmed for limited enhancement	• Dual mission of OPFOR likely • COE increases complexity and numbers required

battalion and BCT level even more difficult to accomplish at home station than is the case today. This is especially true considering the need for complex scenarios, asymmetric OPFOR, and a full set of role players. Moreover, as we will discuss in the next two chapters, enhancements to simulation-supported exercises will not achieve the levels of benefit needed to change the need for live exercises at the CTCs.

The proposed CTC enhancements we examined are important to adapting the CTC to future FCS-equipped BCTs training requirements. These enhancements will support the evolution of the CTCs to train COE tasks and conditions as well as better exercise the full operational capabilities of the FCS-equipped BCTs. Our concerns with regard to the CTC enhancements parallel the concerns for live home station training, namely, the funding risks associated with fielding enhancements.

Of special concern will be the adequacy of training manpower resources. The heart of the CTC training system is the military and civilian manpower for OPFOR, role players, and trainers sufficient for a continued capability to provide highly realistic training scenarios and full feedback. The FCS BCT will be far more complex in terms of use of Army, joint, and interagency operational multipliers, and this increases the requirement for these functions. Additionally, full-spectrum operations will require role players and other expertise to provide for realistic scenarios. The CTCs have proven to be remarkably adaptive to ongoing challenges in these areas, and we are confident that this will continue, but reductions in trainers, role players, and dedicated OPFOR could make continued adaptation difficult. For example, without sufficient manpower support, the CTCs will be limited in their ability to quickly adapt to further changes in the COE. It took the NTC over a year to fully set up the conditions (e.g., scenarios, Arabic-speaking role players, towns) needed to perform a realistic OIF mission rehearsal exercise, and improvements are still being made as the theater situation and mission change. Moreover, a substantial part of this COE capability was funded out of OIF/OEF supplemental funding, which could be difficult to maintain in the long term.

Overall Conclusions on Live Training Enhancements

Based on our examination of future training requirements generated by full-spectrum considerations, we conclude the following.

Live training (both live fire and FOF) will remain the keystone to maneuver BCT training in the 2010 to 2016 timeframe. In fact, we see a substantially increased need for live training events in the future.

Key to effective future live training will be the ability to adapt to the needs for enhanced operational capabilities (e.g., FCS C4ISR) and COE. It will be difficult to increase the quantity of live training over the annual average of 90–100 days we observed in the 2001–2002 timeframe, and there is a limited ability to increase the number of CTC rotations. However, these programs proved sufficient to produce very well trained BCTs, and so an increase in the amount of live training may not be a major need.

Likewise, it will be difficult to improve on the relative quality of those programs. Instead, the key need will be to adapt these programs to the changing training requirements generated by changing operational requirements and advancing operational capabilities within the boundaries of constrained resources. Given the relatively high costs of live training, this will mean that difficult prioritization decisions will need to be made, affecting not only the enhancements prioritized, but their critical capabilities and fielding timelines as well. For example, live training capabilities should likely emphasize improving close combat training as opposed to long-range engagements of armored enemy forces. Moreover, the need to effectively adapt to changed training requirements within constrained resources will likely lead to training strategies with a changed balance of tasks, skills, and echelons trained at home station, the CTCs, and in simulation-supported events.

CHAPTER SIX

Assessment of Planned Enhancements for Constructive Simulations

In this chapter we focus on constructive simulations that support training command and battle staff skills. We assess current capabilities and challenges, as well as proposed enhancements to those capabilities and their associated limitations in the 2016 timeframe. We also draw some conclusions regarding the potential future effect of constructive simulations on the quality of training, the number and duration of training events, and the adaptability of those events.

Current Capabilities and Challenges

In this document we use a definition of constructive simulations provided by the Defense Modeling and Simulation Office (DMSO): "A simulation in which both the people/operators and equipment they are using is simulated."[1] We focus here specifically on constructive sim-

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1 DMSO provides an expanded definition of constructive simulation in its primer on modeling and simulation: "Constructive simulations represent systems and their employment through the use of extensive, complex mathematical and decision-based modules and statistical techniques. A constructive simulation is a computer program. The user inputs data to cause an event to occur then gets the results. For example, a military user may input data on a military unit telling it to move and to engage an enemy target. The constructive simulation determines the speed of movement, the effect of the engagement with the enemy, and any battle damage that may occur. Results can be provided digitally or visually, depending on the type of simulation used. See the DMSO website: http://www.education.dmso.mil/ms_primer.asp?a=s4&b=view&c1=272

ulations supporting training command and battle staff skills at the brigade-and-below levels.

Current Capabilities

Constructive simulation-supported exercises are generally focused on training commanders and staffs on command and control tasks and skills during a command post exercise (CPX) or map exercise (MAPEX).[2] The simulations support this training by providing an automated force-on-force battle that can be indirectly controlled by the training audience, who develop operational orders and issue orders to subordinate and supporting organization role players. The role players "fight" their units or systems on the simulation opposed by other role players who control opposing forces (OPFOR). The role players report back as they would during actual operations. The commanders and battle staffs receive the reports and monitor the progress of operation via actual or simulated C4ISR systems. The intent is that the training audience performs the same tasks and gets the same feedback and results that it would during actual operations, thereby getting a chance to "learn by doing."

The constructive simulations being regularly used for Army training are part of what was until recently called the Army Constructive Training Federation (ACTF) and is now called the Joint Land Component Constructive Training Capability (JLCCTC). The goal of JLCCTC is to provide a federation[3] of eight models that can interoperate in the short term, while migrating to an objective system with fewer simulations that are more highly integrated and use less communications bandwidth.[4]

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2 There are two types of simulated command and staff exercises. In a CPX, the training audience operates out of actual command posts using tactical communications. In a MAPEX, they operate out of simulated command posts using simulated C4 systems.

3 The JLCCTC federation of constructive models uses the High Level Architecture (HLA) that the DoD is developing to let simulations interact instead of the older Distributed Interactive Simulation (DIS) protocols to get better performance. HLA requires smaller amounts of information to be moved on networks to keep entities aware of each other. https://www.dmso.mil/public/transition/hla/

4 The type of intersimulation interaction in JLCCTF is via a "publish and subscribe" model or "PUB-SUB," where members of a federation publish their results on a server and other

The current main constructive simulations in the federation that are most relevant to BCT training are[5]:

- **Joint Conflict and Tactical Simulation (JCATS).** Entities go down to individual soldier and vehicle. Engagement and movement and outcomes are derived from calculations for shooter-target pairings, movement rates considering terrain, weather, type of entity, etc.
- **JANUS.** Has capabilities similar to, but less well developed than, those of JCATS.
- **Brigade/Battalion Battle Simulation (BBS).** Individual organizations, combat systems, and vehicles are grouped into "icons," and the role players control these "units." Outcomes are derived from algorithms or rules based on variables of each unit and the conditions under which the engagement or activity takes place.[6]

To allow the training audience to "see" the operation on C4ISR systems, the Army has developed a Digital Battle Staff Sustainment Trainer (DBST)[7] that allows the constructive simulations to "stimulate" those C4ISR systems.[8]

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members of the federation "subscribe" or get the information from that server.

[5] Other significant Army constructive simulations for training for other echelons and other areas of expertise are the Corps Battle Simulation (CBS), Combat Service Support Training Simulation System (CSSTSS), and Tactical Simulation (TACSIM).

[6] Although JANUS and the Brigade/Battalion Battle Simulation (BBS) are constructive simulations and part of the TADSS currently used by the Army and supported by PEO STRI, they are not part of the JLCCTC. Indeed, BBS is no longer a supported system, meaning there are no dollars allocated to update the system or to provide support for its use.

[7] DBST is a federation of simulations and stimulators that provides a seamless synthetic environment linking virtual and constructive with live training forces. Since the research for this report was completed, the name of this federation has been changed to Entity Resolution Federation (ERF) and is being updated, but the common name used by the user community remains DBST. DBST will be addressed in more detail in Chapter Nine.

[8] "Stimulate" means the training simulation provides stimuli to live Army Battle Command Systems. This allows commanders and battle staff to train using their organic Army Battle Command Systems in larger operational scenarios than are actually represented by "live players."

The type of skills taught to, and exercised by, the training audience can range from strategy to tactics to basic communication procedures and staff standard operating procedures (SOPs). What skills are emphasized is dependent on the skill level of the training audience and the expertise of the training support team. Generally, the higher the training level, the greater the requirements on training support personnel:

- **Crawl.** Establish and execute basic communication skills, information passing, SOPs.
- **Walk.** Plan and execute a combat operation, including monitoring the battle and providing fragmentary orders in a relatively simple operational situation.
- **Run.** Plan and execute a complex adaptation to enemy actions. Events typical of this type of training would include a brigade commander and staff and battalion commanders and staffs planning and carrying out a high-intensity conflict.

Example of a Well-Supported Constructive Simulation-Supported Exercise. The Battle Command Training Program's (BCTP) Battle Command and Battle Staff Training (BCBST) team provides an example of a current, well-respected training organization capable of supporting a "run" level command and battle staff training event. This organization has a number of elements that work together for training success. These are shown in Table 6.1.

Thus, a typical BCBST constructively supported simulation training event is supported by approximately 300 to 400 members of the operations group, unit, and other supporting organizations. [9] Such constructive simulation-supported events are costly to set up and run

[9] This estimate was based on a review of the BCBST team's organization and a review of a memorandum outlining the outside support required for a typical BCT CPX provided to RAND by the BCBST staff. This is a high-end number, but a staff of around 300 is also recommended in TSP 07-1-S-9304, *SBCT Exercise, Brigade Executive Officer (XO) Guide,* section 2, "Description of Brigade XO Duties," coordinating draft, March 2003. These staff would include 31 OCs, 22 Higher Headquarters Role Players/Exercise Controllers (EXCON), 8 Threat and Civilian Personnel role players, 200 Unit role players, and the entire support staff of the Mission Support Training Facility (MSTF).

Table 6.1
Elements of the Battle Command Training Program's Battle Command and Staff Training Team

Feature	Description
Exercise director	The division commander of the brigade being trained
Primary training audience	The brigade and battalion commanders and staffs (they will be in the brigade or battalion command posts carrying out their assigned unit duties on organic equipment)
Supporting unit soldiers	Include other soldiers from the unit being trained, from sister units, or from the brigade's higher headquarters, who will be working to make the simulation "transparent" to the soldiers in the training audience who are manning the Tactical Operations Centers. This will include: • **Division response cell:** About 50 people playing division, other division major subordinate commands and above • **Role players:** Up to 200+ soldiers, including company commanders, platoon leaders, and "pucksters"[a] manning computer workstations and sending operational reports to their company and battalion headquarters.[b]
Operations group	• **OCs:** Approximately 53 military trainers (officers and NCOs) from BCBST staff provide feedback to the unit during the training. Another 30 additional trainers are needed to enhance the battalion focus and cover all the other units that plug in to the brigade. • **Senior observer:** A retired Army general who works with the unit to help with its improvement • **Simulation support staff:** A staff of 54 training support staff of contractors and DA civilians who are responsible for running the technical aspects of the simulation • **OPFOR:** The "enemy" on simulations • **HICON:** Provide inputs into simulation, ensure compliance with rules and workarounds, and otherwise assist in execution of exercise • **EXCON:** Provide scripted intelligence and noncompetitive units and activities, and other activities to provide a "larger picture" • **White cell:** A working group headed by the exercise director and commander of the operations group that makes decisions regarding the course of the training including adjudication of battle results • **Green cell:** Role-plays and provides scripted civilian/NGO play, control Civil Affairs and Psychological Operations (PSYOP) unit icons

[a] The term "puckster" refers to a member of the training team who manipulates simulation entities as part of the simulation run.

[b] These soldiers get some, but limited, training as part of the event, but the cost/benefit tradeoff is unclear, given the time costs of training and execution time.

because they require large numbers of human hours. This training manpower is needed for the five-day exercise as well as for about 90–100 more man-days (spread over several months) spent planning, coordinating, and preparing.[10]

Challenges

Unit leaders and simulations support staff cite support requirements and lack of realism as the two key reasons for the limited use of simulations to support training on battle command skills using constructive simulations:

- **Significant manpower required for quality training events.** As described above, training events are labor-intensive to plan, carry out, and provide the feedback needed to support effective AARs. Events require training of support personnel, as well as significant support from the unit, Army trainers, and contractor personnel. BLUFOR and OPFOR simulations must be carried out by trained personnel. These high levels of manpower are due, in part, to limited scenario-authoring, SAF-authoring, and AAR-support tools. Also, the operation of the simulations can be complex, and unit "pucksters" require specialized training prior to the exercise, the amount of which varies by the "user-friendliness" of the simulation. Those who plan, prepare, and conduct constructive training events have a variety of tools to help reduce their workload, but those tools are generally complex and not particularly user-friendly. To the extent that tools do exist, the tool sets vary among the current simulations. They are designed for use by staff with significant, software-specific expertise and, in many cases, programming expertise. Reports indicate that the tool set for BBS is relatively more user-friendly and adapted than other tool sets, in part because of the close relationship between the BCTP team at Fort Leavenworth and the geographically nearby BBS development team.

[10] This is an estimated number based on interviews with BCBST staff.

- **Limitations on realistic behaviors and outcomes.** Both entity and "rules-based" simulations can provide only limited physical realism due to constraints on how the underlying simulation models represent the effects of urban and other complex terrain, weather, weapon capabilities, and other similar factors. These limitations often result in unrealistic movement rates, communications effectiveness, and engagement results. The realism is also limited for semi-automated force (SAF) behaviors (BLUFOR, OPFOR, and especially noncombatant), including complete lack of complexity in SAF planning and tactics. An unrealistic automated OPFOR, or automated BLUFOR units that simply follow a player-driven unit,[11] can erode the training audience's confidence in the value of the training; simple behaviors on the part of BLUFOR SAF do not adequately support the actions of a human thinking player, nor do such OPFOR SAF provide a significant challenge to a human player. These physical and SAF limitations impact most heavily on dismounted combat and operations in close terrain including urban areas and on COE training. Especially difficult to duplicate in SAF are COE-type interactions, such as the effects of PSYOP, HUMINT, and civilian behaviors. Also frequently cited as a realism constraint is the lack of "fog and friction" in these type of exercises. They lack appropriate effects of randomness experienced in actual operations—for example, units getting lost or disoriented, inaccurate reports—so that units often win engagements that on paper they should have lost. All this limits the complexity of simulated battles compared to those in the real world.[12]

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[11] Such units are sometimes called "tethered" SAF units. They simply follow the movement of a human player who is the commander of the tethered units.

[12] Of course, there is some lack of realism in all simulation-based training compared to actual operations, whether live, virtual, or constructive. However, more of the randomness, "friction" and "fog of war" come into play in live simulations as compared to the more frictionless and deterministic nature of constructive supported simulation-based training for battle command skills.

These limitations on realism lead to uncertainty surrounding overall training effectiveness. The degree of transferability from simulation-based training to actual expertise is unknown.[13] Also unknown is the amount of "negative training," i.e., what occurs if soldiers learn skills and knowledge that do not map onto actual, needed skills/knowledge and may thus be detrimental to soldier or unit behavior.[14] The levels of realism can be greatly improved by an experienced and sufficient support staff and set of role players. For example, the limits on intelligent SAF behaviors can to some extent be mitigated by increasing the number of role players to "maneuver" smaller units on the simulations. But the cost is increasing the size of support and preparation required.

Apparently as a product of these limits on realism and questions regarding accuracy of outcomes, we found a perception that constructively supported exercises better support training procedures than they do tactical adaptation and decisionmaking. That is, there is a belief that simulations can support training tasks like developing orders and practicing the procedures for implementation fire support, but it is more difficult to conduct "run" level training that exercises the highest level of tactical expertise in command and battle staff operations.

Other challenges to leveraging simulations for battle command training cited by unit leaders, simulation center staffs, and BCBST staffs included:

- **Expertise in developing and conducting simulations exercises.** The conduct of an effective simulation-supported battle command exercise is an extremely complex activity. Not only must the scenario be tactically correct and designed to support achievement of the desired training objectives for the specific unit, but the exercise must also be designed with an understanding of the simula-

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13 During our research we found no effort that had statistically examined this area and determined either positive training transfer or the lack of it.

14 This could include taking advantage of the limits of a simulation to consciously "game" the training event for a positive outcome that does not reinforce actual, needed skills. It also could lead to soldiers honestly acquiring the wrong skills because the simulation was unrealistic. As an example, if a company can move through difficult terrain faster than is reasonable, the training audience could develop a false sense of time distance factors.

tions' capabilities and limitations so that "workarounds" can be included. Given that this expertise exists, there is still the recurring need to train the exercise staff, role players, and other support staff that are brought in to support an exercise. This research found limited systemic resources supporting this requirement. As will be covered in Chapter Nine, the Battle Simulations Centers have primarily a technical support staff, and there are a very limited number of officers with a functional area specialty assigned to units to support simulations exercise design and conduct. Moreover we found no formal program to train unit leaders to plan, prepare, and execute this complex type of training.

- **Limited funding for training development.** Training development can help mitigate the need for expertise by providing training support materials. Currently the TRADOC and material developers are charged with providing these materials. We found that the materials available were primarily technical in nature, dealing with the capabilities and operation of the simulations themselves, and not the complex issues discussed above. One exception was a Training Support Package developed by the Infantry School to support a brigade-level CPX for a Stryker brigade. This was an impressive effort. It effectively outlined the requirements, methods, and steps needed to conduct an effective battle command event of this type. However, it did little to reduce the need for expertise and support, and we found no similar products. Without training support materials there is a decrease in the capability to deliver high-quality, replicable events at lower cost. There is also a current lack of procedures and online repositories to effectively share scenarios and training "lessons learned." A related issue is the need for expertise to develop SAF behaviors and effective tools, which are far more than technical issues. The overall issue is that the TRADOC proponents have limited training development resources, and there are other, higher priorities.
- **Duplication of capabilities and lack of interoperability.** Existing constructive simulations have overlapping capabilities, including multiple SAFs. There is a perceived need to decrease the number of different constructive simulations for training currently being

evolved in parallel to reduce overall simulation maintenance and development costs. Such costs include updating changes in code and documentation for equipment performance profiles, unit/TOE databases, terrain datasets, and general software maintenance required by changes in operating systems and related software packages. Interoperability between Army, joint, government and multinational simulation is a goal for current simulations and the focus of a number of conversion efforts. Some constructive simulations do not comply with emerging DoD interoperability standards from the Defense Modeling and Simulation Office (DMSO), including the High Level Architecture (HLA). This raises questions about the future compatibility of current constructive simulations to interoperate jointly in a distributed simulation environment with simulations from other branches of the military and government organizations.[15]

Proposed Enhancements, Likely Benefits, and Limiting Factors

In partial response to these challenges and limitations, the Army is developing two simulations, OneSAF and WARSIM, to eventually replace many of the legacy constructive systems.[16] The intent of OneSAF, in conjunction with WARSIM, is to provide the Army with a next-generation constructive simulation capability. The Army is also developing improved simulation capabilities for the COE within the current constructive federation via the Joint Asymmetric Warfare Simulation (JAWS).[17] Below we discuss the performance parameters described in

[15] An example of interoperability or integration is the integration of Air Force and Navy combat power into Army simulation-based training exercises.

[16] These simulations were not designed to address all the challenges of existing systems. For example, they do not address the lack of expertise in developing and conducting simulation exercises.

[17] Since the original research for this study was completed, the requirements for JAWS have been revised, and the new name for the capability is Joint Nonkinetic Effects Model (JNEF). It reportedly has performed well in recent tests.

the enhancements' requirement documents, limiting factors, and the likely benefits of these enhancements.

Proposed Enhancements

OneSAF. Many of the shortcomings described in the previous section provided the impetus for the development of a single constructive simulation with high-quality semi-automated forces up to battalion level in the BLUFOR and up to brigade level for OPFOR.[18] OneSAF's ORD[19] specifies that it will provide capabilities to support users from three different Army communities:

- **ACR:** Advanced Concepts Research.
- **RDA:** Research, Development, and Acquisition.
- **TEMO:** Training, Exercises and Military Operations.

This section will review only those aspects of OneSAF relevant to the training aspects of the TEMO community. The "One" in OneSAF refers to Army developers' goal of having a single simulation that can supply semi-automated forces to all future constructive, virtual, and live simulations, including modeling entities from the individual combatant up through brigade level. The OneSAF Objective System (OOS) specifications contain all the elements of a full constructive simulation for training, including models of weapons and weapon systems, terrain, environmental conditions, and many other factors. It is a broader simulation than just a model of combat arms units; it is specified to accurately model combat support and combat service support units in Army, joint, and coalition forces, to the brigade level.

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[18] Although the work to develop OneSAF is relatively new, its foundations go back to the development of SAF for Simulation Network (SIMNET) and SAFOR systems as well as MODSAF (Modular Semi-Automated Forces in many variants—Dismounted Infantry SAF, Joint SAF, Medical SAF, etc.), culminating in the OneSAF Testbed. OneSAF Objective System (OOS) is a new application being developed in an object-oriented programming language called JAVA to be platform-independent and run in a distributed environment.

[19] *One Semi-Automated Forces (OneSAF) Operational Requirements Document (ORD)* Version 1.1, dated 22 January 1999.

The goal of OOS development is to replace a number of legacy, entity-based, constructive simulations[20] and also provide a single SAF for Army simulations, including BBS, ModSAF, JANUS, CCTT SAF, and Aviation Combined Arms Tactical Trainer (AVCATT) SAF. OneSAF is also being developed as an "open source" application with the goal of evolving large libraries of Modification Tables of Organization and Equipment (MTOEs), scenarios, and complex SAF behaviors.

OneSAF developers plan to build an authoring tool for composable SAF behaviors. The plan is to create an extensive set of behaviors, both primitive[21] and composite,[22] which will be built into OOS to control the SAFs. Composite behaviors are those that carry out more complicated assessments of the environment and actions by including other primitive behaviors and composite behaviors. The composites are being designed so that a simulation developer or a member of a simulation center staff can modify them and alter behaviors with an authoring tool. The details of the behavior specification and composition mechanisms are still under development.

OneSAF's requirements also include various tools to support the planning, preparation, execution, and AAR of training events. These include tools to develop scenarios, edit unit make-ups, collect and analyze data, and develop automated AAR materials.

Many pieces of OneSAF are defined in the specifications to have broad goals, including many aspects of combat arms and combat service support activities and operations in high-, mid- and low-intensity conflicts. There are also descriptions of peace operations, as well as the specification that OneSAF be "interoperable with WARSIM 2000 such that a consistent, realistic environment is created."

OneSAF is specified to comply with emerging DoD interoperability standards in the HLA. This provides the future possibility of

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[20] OneSAF Objective System: "Leap Ahead Capabilities," www.onesaf.org.

[21] E.g., "if fired upon, drop to prone position."

[22] E.g., "if fired upon, drop to prone position, return fire, compare threat strength to own force strength, if threat strength is significantly larger, pop smoke, disengage in opposite direction from threat."

having each of these simulations interact with other simulations to provide larger training audiences at different echelons. In addition, all future constructive simulations have requirements to be interoperable, not only with other constructive simulations, but with virtual and live as well. This aspect is discussed in greater detail in Chapter Nine.

In sum, OneSAF's specifications offer a single simulation system for brigade-and-below operations that can simulate entities down to the individual combatant with good physical realism in the environment, include SAF with some level of complexity in behavior, and will interoperate with future distributed simulations.[23] If successful, it has the potential to reduce the number of constructive simulations currently supporting battle command skills. It also promises to include a variety of tools to reduce the labor needs of training teams, including tools for scenario authoring, SAF behavior authoring, and automated development of basic AAR slides.

WARSIM. WARSIM is designed[24] to complement OneSAF's strengths by training unit commanders and staffs at the battalion up to theater-level operations, including "joint scenarios for war and operations other than war." It is meant to replace the legacy constructive simulation systems Corps Battle Simulation (CBS), Battle Command Training Program, Intelligence Collection Model (BICM), the Tactical Simulation (TACSIM), and Combat Service Support Training Simulation System (CSSTSS). WARSIM is designed to "support training of unit commanders and their staffs from Battalion up through theater level" and hence, like OneSAF, will support training for BCT training audiences.

The Operational Requirements Document states that WARSIM will provide an environment to "stress and stimulate commanders and their staffs to assess the situation, determine courses of action, and plan and issue new orders in a timely manner, all while using their organi-

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[23] OneSAF will conform to the High Level Architecture (HLA) for simulation reuse and interoperability developed by the Defense Modeling and Simulation Office (DMSO). https://www.dmso.mil/public/transition/hla/

[24] Operational Requirements Document for Warfighters' Simulation 2000, Version 3.7, 4 September 1998.

zational equipment." This includes the Army Battle Command System (ABCS).

Unlike OneSAF, which models combat at the level of target-shooter pairings, WARSIM is a "force-ratio" combat model that uses rules regarding the features of the units that are meeting in order to adjudicate outcomes. WARSIM is also specified to allow units to use their organizational equipment during training.

WARSIM is intended to operate using "fewer than one-third of the personnel it takes to support current simulations." Part of that reduction is planned to come from having WARSIM-based training events require no role players, all of which will be simulated by SAF from OneSAF: "When fully fielded, the WARSIM 2000 goal is no role players unless desired by the senior trainer." It can be inferred that the remaining reductions in personnel will come from powerful authoring and control tools, as well as from automating some aspects of generating AARs. There are reports that WARSIM has already reduced the number of role players needed to maneuver lower-echelon units: WARSIM reportedly originally required three people to maneuver a battalion in a realistic way, but that task has been reduced to a single person. However, that individual reportedly has to now be at least a captain or major with the level of knowledge needed for appropriate simulated battalion-level tactical play.[25]

As was found with OneSAF, there are many diverse implementation-level features specified in the design document. The specifications include very complex, high-level cognitive and communication capabilities, e.g.,

- "4.1.1.3.4 Command and Control (C2). WARSIM 2000 must simulate the doctrinal C2 and decision making processes for automated force units and support these processes as performed by the headquarters in the training audience."

The specifications also include a wide variety of very detailed activities, e.g.,

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[25] It should be noted that these reductions are at the level of "pucksters" or people manipulating the simulation entities to provide intelligent movement behaviors.

- "4.1.1.3.7.7 Mortuary Affairs. WARSIM 2000 will simulate the activities of concurrent return or internment and account for remains processed, evacuated, and, as ordered, buried." WARSIM 2000 will also model NBC-contaminated remains.
- "4.1.1.3.7.10 Religious Support Operations. The simulation must simulate the effects of religious support operations on the battlefield. In addition to the effect on human factors, the simulation must provide information on simulated unit morale, cohesion, and perceptions to the training unit chaplain."
- WARSIM also includes such things as detailed modeling of the weather, including barometric pressure, and the effects of solar flares on communications.

Like OneSAF, WARSIM specifications include descriptions of the types of exercise support that are to be part of the system. This includes scenario-generation capability, tools to help commanders identify training objectives, and tools to define the forms of missions, tasks, unit relationships and resources for the training event. The automated AAR capability in WARSIM is intended to "support AARs within two hours of demand," although the specifications do not make clear for which of WARSIM's many training audiences this AAR would be generated.

The Joint Asymmetric Warfare Simulation (JAWS). JAWS is an attempt to bring, at low cost, simulated familial/tribal, social, and cultural events characteristic of low-intensity conflicts and the COE into simulation play of any existing constructive simulation such as JCATS and the JLCCTC.[26] These constructive simulations were largely built to support simulation of mid- to high-intensity conflicts and lack underlying models of social, political, economic, and religious influences in a population. As of the writing of this report, there was no plan to include JAWS or JAWS-like capabilities into OneSAF.

[26] Since the original research for this study was completed, the requirements for JAWS have been revised, and the new name for the capability is Joint Nonkinetic Effects Model (JNEF).

JAWS[27] is based on the Joint Regional Analysis Model (JRAM) as a driver for asymmetric events. JRAM provides a model of how, over time, a faction ("side") deals internally with interacting issues such as religious, political, and economic forces and "satisfaction levels." These issues then influence the faction's cohesiveness and leadership. In turn, factions interact and influence each other in many ways, including alliances.

Factions are influenced by the actions of BLUFOR and REDFOR ("red" or opposing forces) via "input" and "output" rules. The JAWS input rules will translate how the actions ("who did what to whom, and how severely") of simulated forces in constructive simulations (e.g., JCATS or BBS) are translated into changes in satisfaction levels of the factions in JAWS. The result is that combat effects in the constructive simulations affect the underlying economic, political, and social concerns of the various factions. The variation in the factions' satisfaction levels then triggers the output rules that provide appropriate information to the Green Cell team on the states of the factions and generate events in the constructive simulation run.

An example from JCATS would be using force to quell a civilian demonstration by a faction, which affects the satisfaction of the faction with the level of personal security. This then leads to both a destabilization of the faction leadership (a JRAM internal effect) and an increase in the number of ambushes in the faction's territory (an effect in the constructive simulation).

In sum, the requirements documents for both OneSAF and WARSIM have set high and broad goals for their development and success. To the degree that they reach these goals, they would provide interoperable constructive simulations for command and battle staff training for the BCT. They would accomplish this with reductions in training support manpower and improved realism through higher-quality SAF, greater physical realism, and improved training support tools. In addition, JAWS would seek to improve realism for SOSO operation and the COE.

[27] Joint Asymmetric Warfare Simulation, Proof of Principle/Prototype in Progress Review, 13 June 2005.

Likely Benefits and Limiting Factors for Constructive Simulations

Given the goals and potential improvements that OneSAF, WARSIM, and JAWS may provide, there are a number of areas in which the simulations are likely to be successful, and also areas in which the simulations may be limited in their success or subject to substantial risks. In this section we review those limits and areas of risk for OneSAF and WARSIM, and assess the likely benefits that will result.[28]

Constraint on Training Benefit Due to Increased Training Requirements. The primary constraint on the training benefit likely to be derived from constructive simulations is that brigade-and-below operations will become far more complex and harder to effectively model.[29] Rather than focusing on engagements between conventional forces, the training requirement has evolved to one of facing an asymmetric threat that will likely include irregular methods (e.g., small, dismounted "hit and run" type engagements, often in close terrain and against support as well as combat units). Interactions with civilian populations will be an expected part of all operations. Training the use of kinetic as well as nonkinetic capabilities and JIIM coordination and cooperation will be required, likely down to company level. C4ISR capabilities will complicate replication of the input that will shape battle command execution decisions. As the amount of digital information traffic increases, the burden on OCs to track that content also increases. In the 2016 timeframe, there will be very limited automation to ease this burden of monitoring and tracking. There will be some improvements in accessing relevant information for AARs *post hoc,* but this will not provide a significant decrease in the workload of the OCs, especially in light of the increased amounts of information to track.

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[28] JAWS will not be reviewed further here, since at the time of this report it was still early in its development. However, we note that it holds promise for improving realism for SOSO operation and the COE.

[29] That is not to say that COE events cannot be conducted. JCATS has shown sound capabilities in this regard, for example for conducting small-unit MOUT. However, the number of expert role players needed for a JCATS BCT-level training event involving a large number of small units in complex terrain would be far beyond the number that would be reasonable to support a unit training event.

Reduction of Duplication, But at the Price of Some Technical Risk to Some Goals for Simulation Training. Focusing on OneSAF and WARSIM, the Army will clearly achieve its goal of decreasing the number of different constructive simulations for training. As a result, overall simulation maintenance and development costs ought to decrease.

The reduction, however, will carry some technical risks. As described in its specifications, OneSAF is a large system with development goals that span a wide breadth of uses. There are unclear tradeoffs in design/development necessary to create a simulation system that is capable of providing high-quality support to the diverse needs of researchers, analysts, planners, and trainers across demanding ACR, RDA, and TEMO applications. The question facing the developers of OneSAF is how the tradeoffs in design, development, and system performance will be made so that the simulation is still useful to each of the user communities. The example of the expensive and unsuccessful effort to develop the broadly targeted Joint Simulation System (JSIMS)[30] should stand as a fairly recent cautionary tale to developers of complex simulation systems with broad goals.

An example will help highlight some of the issues involved. It is unclear whether the level of detail in physical realism in OneSAF, and modeling to the individual combatant, is required to achieve a good quality of simulation-based training for BCT commanders and battle staffs. It is possible that having company-level entities engaged in MOUT operations and using force-ratio algorithms for combat outcomes may be all the level of detail that is required to exercise the battalion commander and his battle staff. Having simulated entities at the levels of individual soldiers taking part in room-clearing operations may not provide more realistic combat outcomes, and doing such operations at the battalion or brigade level in a Fallujah-like operation could pose problems for the simulation engines, as further explained below.

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[30] C. Paul, H.J. Thie, E. Reardon, D.W. Prine, and L. Smallman, *Implementing and Evaluating an Innovative Approach to Simulation Training Acquisitions,* Santa Monica, CA: RAND Corporation, MG-442-OSD, 2006.

There is an additional technical risk of success in specifications for OneSAF and WARSIM, given their very broad goals/application areas and general level of underspecified features. Historical experiences with development of complex simulations (e.g., JSIMS), anecdotes regarding the development of other simulations, and experiences with software development projects more broadly, suggest that many of these underdefined "wish list" system features in the ORDs will not be implemented effectively, or at all. Given the number of requirements, the apparent lack of an "importance" ranking or prioritization in the ORD, and the absence of good performance metrics for these features, it is unclear which capabilities will actually be produced and delivered in the end, and what quality those features will attain.

The realism and detail of physical environments pose an unknown risk for the real-time operation with many entities. The level of detail in the specifications would appear to demand a great deal of computation on the part of OneSAF during engagements of moderately large numbers of combatants. It is unclear whether OneSAF could support the simulation of a brigade-level operation in a MOUT environment at the level of specificity outlined (e.g., ballistics of weapons, smoke, weather effects, SAF behaviors, etc.). For example, there are required computations to model the penetration of each bullet through each piece of material in MOUT environments (e.g., sheetrock walls, overturned tables and mattresses as barricades) until the bullet is no longer lethal. Multiply those calculations by the number of bullets that might be in flight at any given movement in a battalion- or brigade-level MOUT engagement to get some sense of the computational load on the simulation engine. Then add the computations for movement of each entity, as well as possible decisions that SAF are making to plan routes, use cover, etc., and the numbers grow significantly.

Improvements in Interoperability. The Army is likely to achieve some level of interoperability among training simulations. For example, OneSAF and WARSIM will lead to an increased opportunity of "wrap-around" for live training, which can increase the quality of training and the size of the training audience. Moreover, interoperability will lead to a greater opportunity for JIIM training, e.g., CAS from Air Force airframes and SEAL teams operating in the BCT AO.

While seemingly posing limited technical risk, interoperability between simulations has frequently proved difficult to achieve. The differing timelines for development and the possibility of changing standards further complicate achieving this worthy goal. See Chapter Nine for a discussion of "limiting factors" with regard to interoperability.

Limited Improvements in Realism. This is primarily because the artificial intelligence (AI) for SAF in OneSAF will remain limited in its ability to produce complex behaviors for realistically maneuvering, engaging SAF. OneSAF should provide improvements in the underlying simulation models to better represent buildings, underground passages, and weapon effects, among other important entities and effects for MOUT/COE. Similar to the trend in commercial "games," the combat between entities will become more realistic as more aspects of the physical simulations are improved. In general, aspects of OneSAF that involve simulation of physical objects or systems will improve in quality during this period, potentially providing increases in the quality of training events.

To a limited degree, improvements in SAF behaviors and "rules" are also likely to increase the realism of training events. However, a significant concern in this area is what is predicted to be very modest improvements in simulation realism from improved AI capabilities in SAF. Our review of commercial organizations, researchers, and leaders in the AI field suggests that addressing the core concerns about AI will not be possible until well after 2016, due mainly to the following factors:

- Capabilities for fully automated complex behaviors[31] in run-time SAF in simulations with many entities do not appear to be achievable by 2016 in commercial games or training simulations.[32]

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[31] We make a distinction between simple and complex behaviors. Simple behaviors are those that are triggered by detection of features in the environment, e.g., if the player takes fire, the player ducks for cover. Complex behaviors are those that require the generation and management of multiple goals, to include modeling the intended actions of your adversary, e.g., if the player's platoon takes fire, the player orchestrates the platoon's reaction, determines whether additional support is necessary and in what form, etc.

[32] This conclusion is supported by the results of an 18-month study summarized in portions of a book published by the National Research Council: R.W. Pew and A.S. Mavor, (eds.),

- Progress in the area of creating easy-to-use authoring tools for complex skills still requires academic research.
- Developing tactically realistic SAF behavior will require higher levels of shared planning, spatial reasoning, and communication between SAF elements than are present in current and near-future simulations. It will also require strong authoring tools and high levels of tactical SME participation. And even with such expertise, development will be difficult and time-consuming, and will require continuous updating and maintenance.

Some Reductions Possible in Manpower Needed to Support Training Events, Although Advances Will Be Relatively Small in the Larger Picture. Our research on the use of constructive simulation capabilities indicates that a primary reason for relatively low usage is the high unit workload required to plan, prepare, and support simulation-supported exercises. The OneSAF and WARSIM ORDs address this limitation by proposing the development of an open architecture and various support tools (e.g., scenario authoring tools, SAF behavior authoring tools, and AAR automation and development tools). We find that all these initiatives proceed in the appropriate direction, but that caution is advised regarding the magnitude of net dollar and time savings, especially considering that the COE is generating greater support requirements that potentially offset any gains achieved from the new tools. For example, the development of WARSIM has reportedly made limited progress in achieving its goal of operating using "fewer than one-third of the personnel it takes to support current simulations."

The open architecture of OneSAF could encourage more widespread scenario-authoring and related content development (e.g., force lay-downs, map overlays, simulated communication), especially if high-quality development tools are distributed as part of a OneSAF software development kit. This could lead to higher-quality training events and some decreases in the labor needed to plan the training and train support personnel. However, the percentage decrease in man-

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Modeling Human and Organizational Behavior: Application to Military Simulations. Washington, D.C.: National Academy Press, 1998.

hours required will likely be small, as training preparation will still require high levels of human expertise.

SAF behavior authoring tools are also likely to save some time in providing realistic training. However, decreases in labor requirements from SAF are similarly likely to be limited in the 2016 timeframe. A primary reason is that the methods for authoring complex behavior in OneSAF do not appear to yield skills that will be complex enough to replace significant numbers of BLUFOR and OPFOR human players. The method of combining low-level skills into higher-level skills sounds reasonable, but there are real limits to the amount of intelligence that can be "accreted" in this fashion.[33] More intelligent SAF will require complex architectures that allow these entities to carry out adaptive planning and execution, with realistic communication and collaboration between entities. Moreover, these actions will need to be carried out in real time.

Such issues are at the cutting edge of research in artificial intelligence. Although primitive versions of such systems currently exist and appear to move applications research into complex, real-time simulation environments,[34] they do not appear to be able to provide the level of fidelity and real-time performance that is required by 2016. Without significant improvements from OneSAF AI, there will still need to be role players to provide complex aspects of the simulation, such as providing appropriate reports, C4, and decisionmaking for simulated units. When such artificial intelligence is available later, it could provide some significant decrease in human SAF controllers, especially for behaviors at the soldier or very small unit level.

Proposed AAR tools also offer potential labor savings. For example, improvements will allow for better data-logging and will provide simple automated tools for building standard libraries of AAR brief-

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[33] Think of teaching a dog many simple tricks and then trying to combine those simple tricks into a complex behavior that involves planning, communication, and cooperation between entities. Simple tricks simply do not scale up into complex behaviors without complex underlying mechanisms for spatial reasoning, decisionmaking, and communication, among other aspects of complex cognition.

[34] Soar Technologies is doing Defense Advanced Research Projects Agency (DARPA) research and applying its methods to military applications. www.soartech.com

ing slides. While these improvements will increase AAR quality and speed preparation somewhat, they will not significantly decrease the time or number of trainers required. With transformation and the COE, operations are increasingly complex, and this makes the functions of tracking what happened, and especially why it happened and how to do better, increasingly ones that—without significant advances in AI—will continue to require expert human trainers.

In sum, better tools developed in this timeframe will speed the work in several categories of training preparation, execution, and AARs, but not to a degree that will allow the elimination of significant amounts of manhours. This is due primarily to the limited capabilities of the tools without greater near-term advances in artificial intelligence. Future systems, developed beyond the 2016 timeframe, may give trainers access to sufficiently powerful tools to realize significant time savings in some exercise and AAR preparation tasks, but the likely gains in this area appear limited for the period considered in this report.

Funding and Training Development Risks. Funding risks are highly related to technical risks. If the technology solutions prove difficult to solve, additional funding is often difficult to attain. The likely result is a compromise between costs and capabilities.

A likely major issue will be training development resources for simulations development. Effective SAF behaviors, rules for operational outcomes, operational analysis techniques, and many other highly complex activities are a critical component to full achievement of the requirements outlined for these training simulations. Developing and maintaining the underlying knowledge basis to model these components is a daunting task, and an area in which only a modest capability has been achieved in current simulations.[35]

Given the ambitious but broad expectations outlined in the requirements documents we reviewed, the likely outcome is that the capabilities achieved will fall far short of those needed to make a major increase in the training benefits.

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[35] OneSAF and WARSIM development does not appear to address the need for funding to continuously develop training scenarios and related content.

Existing Challenges Not Addressed by New Enhancements. In a number of areas, the proposed enhancements do not address the challenges that previously existed for constructive simulations (see the earlier description in this chapter). One such challenge is in establishing the training effectiveness of constructive simulations. Concerns over the actual training benefits from simulation-based training of command and battle staff skills, and specifically concerns with possible negative training (e.g., gaming the system to win using unrealistic actions) will continue unless more specific research attention is devoted to these areas. Focused efforts are needed to quantitatively measure the skills and knowledge acquired in constructive simulation-based training, as well as testing, in applied settings, the relative amount of positive, or appropriate, productive transfer compared to negative transfer.

Another continuing challenge is to sufficiently prepare unit leadership for constructive command and battle staff training. Professional development in this area integrated into the POIs of the schoolhouses would be a major step to better prepare unit leadership to conduct "walk" and "run" level exercises of command and battle staff skills.

Conclusions

Table 6.2 provides a summary of the likely benefits and limiting factors resulting from improved constructive simulation technologies in the 2016 timeframe. We conclude that the achievable benefits and improvements potentially offer real, but limited, increases in the quality, quantity, and adaptability of battle command type training exercises over levels seen in the pre-OIF period for heavy BCTs. The basic issue is that while the technologies are somewhat more capable, the COE has greatly increased the complexity of the training goals these exercises are expected to achieve.

Enhancements to current constructive Command and Battle Staff training offer increases in the quality of future training events, but significant gaps will remain. The OneSAF, WARSIM, and JAWS simulations will likely increase the representation of social and physical realism and METT-TC for COE and MOUT in the 2016 timeframe.

Table 6.2
Enhanced Constructive Simulation for Battle Command Skills: Likely Benefits and Limiting Factors

Enhanced Capability	Likely Benefits of Enhancement	Limiting Factors
Battle Command Skills (WARSIM, OneSAF, JAWS)	• Significant reduction in duplication • Some improvement in interoperability – Increased JIIM potential – Ability to train on tactical ABCS – See Chapter Nine	• Some technical risks to successful achievement • See Chapter Nine
	• Limited improvement in realism – Better physical aspects – Some improvement in SAF behaviors and "rules"	• COE greatly increases requirement • Technical risk for OneSAF because state of AI not sufficiently advanced by 2016 to provide complex behaviors in complex environments • Funding risks especially for training development
	• Some reduced support needs via: – Scenario authoring tools – SAF behavior authoring tools – AAR automation and development tools	• COE requirements generate greater support requirements than tools offer improvement • Technical risks of advances in AI, needs for manpower to prepare and carry out exercises, operate SAF, and create high-quality AARs will remain high • Funding and training development risks

Through greater interoperability, the simulations will also allow more complex training: for example, by offering a greater opportunity for JIIM training and a constructive wrap-around to live training, e.g., CAS from Air Force airframes and SEAL teams operating in the BCT AO.

Despite these worthwhile advances, other trends in training technologies (especially in the area of AI) are likely to limit the level of quality improvement that can be expected in the 2016 timeframe. For example, we see high risk in the ability of constructive simulations to realistically replicate the combat results of large numbers of small units, such as dismounted infantry in MOUT operations, without large numbers of role players. This continuing lack of fidelity will be driven largely by the gap between what is needed and what improved SAF can offer in terms of realistic behaviors in the 2016 timeframe.

Efforts to improve the quality of exercises will also be hampered by the limited ability to simulate the complexity of SOSO operations in the COE. This aspect of realism is being addressed by the JAWS model; however, its effectiveness at simulating such realism and appropriately tying these elements into combat simulations to challenge commanders and battle staffs has yet to be demonstrated.

Finally, significant manpower resources, both expert trainers and support personnel, have traditionally been required for high-quality, adaptive training events; our assessment suggests that this will continue to be true in the 2016 timeframe. Part of the problem with the "quality" of constructive events in the past has been that the required manpower is often unavailable. To the extent that constructive events are short of manpower in the future, quality will continue to be affected, despite advances in constructive technologies.

Adaptability will improve in some areas, but overall adaptation to revised COE training requirements will have limited improvement. The new simulations offer some improvement in the speed and ease required to adapt training content (e.g., develop a scenario complete with terrain, unit TOEs, etc.) via improved authoring tools. The new initiatives also offer some potential for more easily developing and distributing scenarios via the decision to make OneSAF an open architecture. Improvements in automating AARs and providing integrated AAR authoring tools will also provide some added flexibility.

However, given new and changing COE training requirements, the difficulty of adapting training events to unit needs will remain high. Increasingly complex training events will still take significant amounts of training support manpower to design, execute, and evaluate. For example, even though automated AARs will generate an increased amount of useful support materials, highly trained OCs will still be needed for each event to focus on making clear the specific causes and effects of outcomes so that the training audience gets the benefit.

The quantity of events will probably not be significantly increased in the 2016 timeframe. One of the keys to a greater number of constructive events being undertaken is a reduction in the support requirement for such events. As argued above, the enhancements described provide only marginal decreases in preparation and AAR development and delivery times for such events. Further, the gains will have to be offset by the increase in support needed due to increasing training requirements.

Some increases in the use of constructive simulations are likely to result from increased interoperability. For example, wrap-around for live training will be much more possible, and there will be increased potential for joint simulation-based training. However, because events requiring such interoperability will also probably require high support, it is unlikely that the total number of training events will increase significantly.

In short, some of the historical limitations and problems of constructive simulations to hone command and battle staff skills for the BCT have been partially addressed by the capabilities outlined for OneSAF, WARSIM, and JAWS. However, the level of capabilities that is likely achievable in the 2016 timeframe will not create large labor savings nor result in large increases in training quality. Instead, in the period covered by this assessment, human training support is likely to continue to be required to achieve more high-quality, well-adapted simulation-supported training events.

CHAPTER SEVEN

Assessment of Planned Enhancements for Virtual Simulations

In this chapter we focus on virtual simulations, which are used to train a variety of individual soldier, operator, and maintainer skills, as well as crew-and-above collective tasks and skills. We assess current capabilities and challenges, as well as proposed enhancements to those capabilities and their associated challenges in the 2016 timeframe. We also draw some conclusions with regard to the potential future effect of virtual simulations on the quality of training, the number and duration of training events, and the adaptability of those events.

Current Capabilities and Challenges

The use of virtual simulations for training is a key aspect of future training as the Army transforms[1] and has been highlighted as a "revolution" for meeting future training needs.[2] One of the clear trends in this area is the movement toward interoperability of systems and sharing of components. Increasingly, there will be a blending of the underlying capabilities of virtual with constructive simulations (e.g., terrain modeling, SAF).

In this chapter we have defined virtual simulations using the DMSO definition: a simulation in which live people/operators use

1 "Objective Force Doctrine, Training and Leader Development Plan," 17 April 2003, TRADOC.

2 Briefing entitled "Training Revolution II," BG Easton, TRADOC, undated, received August 2005.

simulated equipment.[3] This definition encompasses two types of virtual simulation-based training with different user interfaces: physical interfaces and digital or computer-generated interfaces that look and act like the physical equipment. This distinction has been referred to in some training communities as the difference between a training *simulator* (includes physical interface) and a training *simulation* (without physical interface).[4]

Regardless of the type of interface, there are very important issues of fidelity involving the underlying simulations that can lead to large differences in the quality of the training delivered. If the underlying simulation does not accurately represent the operation of the real equipment, there are serious risks that the simulations will train inappropriate knowledge and skills.[5]

Given the breadth of virtual training applications for Army training,[6] we have divided the simulations/simulators into three subcategories for our analyses, each focusing on different training audiences and skills:

1. Soldier/operator/maintainer skills, e.g., trainers for operators, equipment maintainers, and individual soldiers.

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3 As with the definition of constructive simulation, DMSO provides an expanded definition in a primer on modeling and simulation: "Virtual simulations represent systems both physically and electronically. Think of a video game or a cockpit mockup used to train pilots—these are virtual simulations."

DMSO website: www.education.dmso.mil/ms_primer.asp?a=s4&b=view&c1=272

4 For the discussion in this chapter, we consider a simulator to be a trainer that has a very high level of physical fidelity to the actual operation of the equipment, e.g., motion in an aircraft trainer.

5 Two interesting cases of this kind of risk reportedly occurred with early versions of the simulation-based training for operators of TOW and Dragon missiles. In each case there were serious differences between the simulated operation of the training system and the actual operation of the real system that would lead to soldiers missing their targets when operating the actual system.

6 Including earlier examples taken from a briefing entitled "Changing the Way We Train: U.S. Army Virtual Training Overview," TRADOC Program Integration Office (TPIO)-Virtual, 27 June 2005, and overview titled "Ground Combat Tactical Trainers: Product Brochure," PM GCTT, April 2005.

2. Crew/squad skills, e.g., trainers for fire squads/fire teams and crews.
3. Multi-echelon collective skills, e.g., at platoon/company level.

Note that these skills can range from practicing simple procedures (e.g., going through the power-up process for a piece of complex communications equipment) through simple problem-solving (e.g., diagnosing faults in circuits or in a patient presenting symptoms) to complex problem-solving (e.g., command and control of a team in a room-clearing operation, leading a company of armor in an engagement with OPFOR, or negotiation with a tribal elder).

Of potential note to some in the Army training community are two products missing from the listed virtual simulations: the Virtual Tactical Operations Center (V-TOC)[7] and the recruiting game "America's Army."[8] For the purposes of this study, we have classified V-TOC as a collaboration technology rather than as a simulation for training; V-TOC contains no underlying simulation model of a task or equipment that is the driver or focus of the training. The America's Army game was originally not designed or intended to be a training tool, but instead a way to generate interest in and knowledge about the U.S. Army as a career. However, there are recent efforts on the part of some Army developers to create a variety of training applications using the underlying architecture of the America's Army game.[9]

Current virtual simulations in use by the Army[10] and relevant to the BCT include training systems for:

- Soldier/Operator/Maintainer Skills:
  - Basic Electronics Maintenance Trainer (BEMT).
  - Maintenance Training Systems for various vehicles and weapon systems.

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7 J. Belanch, K.L. Orvis, and R.A.Wisher, *Web-Based Collaborative Learning: Communication Between Learners Within a Virtual Tactical Operations Center,* Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, RR-1808, 2003.

8 www.americasarmy.com/

9 http://info.americasarmy.com/projects.php

10 Ground Combat Tactical Trainers: Product Brochure, PM GCTT, April 2005.

- Language trainers.
- Laser Marksmanship Training System (LMTS).
- Engagement Skills Trainers for marksmanship and "shoot/don't shoot" decisions.
- Call For Fire Trainer (CFFT).
- Interactive Multimedia Instruction, e.g., Recognition of Combat Vehicles (ROC-V) Trainer, America's Army game.[11]

- Crew/Squad Skills:
  - Engagement Skills Trainers for fire squads/fire teams.
  - Conduct of Fire Trainer (COFT) and other crew trainers.
  - Virtual Combat Convoy Trainers.
- Multi-Echelon Collective Skills, e.g., CCTT.

The current virtual trainers are generally accepted as providing value in today's training applications. Virtual simulations provide the potential to increase productive training, including allowing more iterations, faster reset, and more varied terrain and conditions than live training. Many tasks deemed too dangerous for frequent live training can be trained in virtual trainers. Many of the individual and crew-level systems include some degree of automated feedback on speed and accuracy of skill development. Some also include a series of tasks or curricula that automatically increase in difficulty as skills improve.

In addition, current virtual simulations can have other positive training aspects, both relative to live training and generally. For example, while few dispute that live training is the centerpiece of tactical training for combat units, the virtual simulations have some advantages over live training with MILES. These include:

- Weapons penetration effects can be directly seen by the soldiers, including appropriate penetration of walls and other barrier objects.

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[11] http://info.americasarmy.com/projects.php
There are recent efforts on the part of some Army developers to create a variety of training applications using the underlying architecture of the America's Army game.

- Firing cues can be semi-realistic so that reports of enemy weapons can be seen and heard at appropriate levels.
- For close engagements, the shooter can choose the specific part of the target to engage.
- Through both impact signatures and tracer rounds, there can be more visual cues to shooters to help them understand errors and to correct them. This increased level of feedback can lead to increased hit probabilities for many weapon systems.
- The effects of many weapon systems are or can be more easily replicated, including mines, artillery and mortars, IEDs, Claymore, hand grenades.
- Crews and gunners can use proper live-fire methods (e.g., lead the target).

However, there are also general and specific limitations and challenges to the effectiveness of current virtual simulations for training:

- Although virtual simulators exercise many aspects of the manual skills of operations equipment, many virtual simulations do not exercise these manual skills nor do they provide full physical/movement and spatial/orientation cues that are critical to expert performance in some tasks, such as driving a tank.
- Dismounted simulations lack physical communication cues that would occur in close combat environments, e.g., feeling a shove from a fellow trainee when it is time to move out.
- There is a lack of automated OPFOR with challenging/realistic behaviors.
- Few physical fatigue factors are included.

Virtual simulators are widely used in a number of areas, including aircrew training. The payoffs exist but are not fully documented.[12] Some tasks, such as emergency procedures for when an engine fails on

[12] R.J. Pleban, D.E. Eakin, and M.S. Salter, *Analysis of Mission-Based Scenarios for Training Soldiers and Small Unit Leaders in Virtual Environments*, Research Report 1754, U.S. Army Research Institute for the Behavioral and Social Sciences, 2000. B.W. Knerr et al., *Virtual Environments for Dismounted Soldier Training and Performance: Results, Recommendations,*

aircraft, when practiced on a simulator with good fidelity, have very close transfer to the actual behaviors, and, for safety reasons, might be difficult to train live on a frequent basis. This is very different from having to move in a simulated environment (e.g., practicing room-clearing) without the tactile and spatial feedback.

There are also ample opportunities for mislearning or "negative training" if the fidelity is too far from actual experience (e.g., timing of system responses to stimuli is not realistic, rates of movement are unrealistic).

Proposed Enhancements to Virtual Simulation-Based Training, Likely Benefits, and Limiting Factors

This analysis will cover the broader spectrum of the three subcategories described earlier.

- Soldier/Operator/Maintainer Skills Virtual Simulations Trainers.
- Crew/Squad Skills Virtual Simulations Trainers.
- Multi-Echelon Collective Skills Virtual Simulations Trainers.

Soldier/Operator/Maintainer Skills Trainers

The FCS System Training Plan (STRAP) outlines requirements for these types of trainers for all of the FCS systems.[13] There are many valuable applications of such technologies to FCS systems, including operating UAV/UGV, emplacement of IMS, and operation of C4 systems. While there are requirements that these trainers be embedded in the operational system, there are also requirements for stand-alone trainers to support institutional training or unit programs where appropriate. Additionally, there are various additional requirements for individual virtual trainers for a wide range of knowledge and skills (e.g.,

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and Issues, Technical Report 1089, U.S. Army Research Institute for the Behavioral and Social Sciences, 1998.

[13] *Operational Requirements Document for the Future Combat Systems, Appendix F, Systems Training Plan (STRAP),* Headquarters Department of the Army, April 2003.

language, medical procedures) that will support FCS BCT training in the 2010–2016 timeframe.

In the 2016 timeframe, there will also be significant growth in this area of virtual simulations from "serious games" that teach individual tactical knowledge and skills, such as the language trainers with improved voice recognition. The visual and physical realism in serious games will improve significantly, as it will for the other types of virtual simulations. This area has great potential for producing applications that teach complex cognitive skills and understanding, as well as teach and allow leaders to exercise adaptive decisionmaking and recognition-primed decisionmaking.[14] Examples could include individual trainers for recognizing and responding to different types of ambush threats, room-clearing problems, and SOSO challenges. The applicability of such tools, in terms of which audiences might be best affected, is unclear. Research and development will establish which tools are effective at different echelons of leadership.

As the physical fidelity increases, the costs of achieving fidelity will generally decrease as underlying simulation engines improve and simulator sensors and feedback mechanisms become cheaper to produce. There will be continuing debate over the degree of skill transfer with different interface fidelity (e.g., Xbox-like controllers compared to physically realistic M-4 simulators with movement buttons on front grip). Such debates will have to be informed by careful research. The continued development of these types of trainers appears to be assured, as they are part of the system requirements documents and not under nonsystem funding lines. However, training development has been underfunded during product development in the past, so the level of development for these trainers has yet to be determined.

The achievement of realism will be more difficult for training more-complex cognitive skills and tasks that involve applying knowledge to problem-solving. Here the issue is developing and maintaining high-quality training content, such as detailed vignettes that require complex problem-solving skills to successfully work through to suc-

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[14] G. Klein, *Sources of Power: How People Make Decisions,* Cambridge, MA: MIT Press, 1999.

cess. Without an adequate level of true expert support to develop and maintain such content, the training benefit will be limited and negative learning is even possible.

In summary, while there will be limits on physical realism for some tasks, and possible resource issues involved in developing and maintaining the full range of desirable content, the capabilities of these simulations should be widely available and capable of playing a key role in supporting FCS-equipped unit individual training.

Crew/Squad Skills Virtual Simulations Trainers

As with individual and operator trainers, the FCSs' System Training Plan and its Operational and Organizational Plans outline requirements for these types of virtual trainers for FCS crews.

Our conclusions on the value of these enhancements are somewhat different for crew and squad trainers. Individual virtual crew trainers are to be embedded in the operational hardware. Our conclusions on the benefits and limitations of crew trainers are similar to those for operator trainers. That is, there seems to be little technical risk, and the widespread availability has obvious advantages to "anywhere, anytime" training. The main limitation will be the affordability of building such training capabilities (e.g., the ability to render virtual targets realistically in the vision blocks and infrared sights) into FCS systems.

The potential for virtual squad trainers is a far more complex matter. The primary initiative is under the Soldier Combined Arms Tactical Trainer (CATT) program. Soldier-CATT is intended to combine training environments for both dismounted leaders and soldiers, as well as PC-based, reconfigurable vehicle simulators to support "walk-level" collective skills training[15] as well as sustainment training[16] for current and future FCS-equipped BCT forces.[17] Suites of Soldier-CATT

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[15] Operational Requirements Document for the Soldier Combined Arms Tactical Trainer, 8 June Revised 2004, approved August 2004.

[16] Although the ORD defines Soldier-CATT as a mission rehearsal tool as well as a training tool, the mission rehearsal aspects of the system will not be reviewed.

[17] Future Block upgrades are intended to provide training to Land Warrior–equipped Units of Action.

capabilities are designed to train "from individual Soldier training at the squad level up to platoon and infantry company leader training." Soldier-CATT is intended to train light infantry, SBCT, Ranger, SOF, and BCT leaders and soldiers in "infantry, RSTA, and selected maneuver and maneuver support tasks for the full spectrum of operations in a combined arms and joint environment." Training would include exercises on bringing joint fires and effects to bear, operating remotely controlled weapons and sensor systems, integrating technologies for the Land Warrior–equipped dismounted infantry. Soldier-CATT is intended to provide training for all types of battlefield settings, as well as for stability and support operations, including operations in urban environments.

A major difference between Soldier-CATT squad trainers and current versions of EST is that Soldier-CATT will use semi-automated forces (OneSAF). EST uses scripted vignettes, thus limiting the learning variations provided to the training audience.

Our discussion in this section deals with the Soldier-CATT virtual collective trainer. The current Soldier-CATT concept appears to limit this collective training capability to squad level.[18] The goal is to provide "immersive" training for dismounted soldiers and leaders. This immersion will allow the dismounted soldier to "see the battlefield in three dimensions, control subordinate virtual soldier through voice recognition/voice synthesis, and communicate via FM voice communications." Immersion is defined at threshold as basically projection screens around 60 degrees of the soldier's horizontal view, by 45 degrees vertically. Objective goals include 360-degree views, via either head-mounted displays or complex projection systems.

Like many of the other requirements, the Soldier-CATT ORD contains many specifications at many levels of detail, and with few measurable, technically specified requirements. Moreover, it includes some goals that will be very difficult to attain, e.g., "Produce battle-

[18] Above squad level, the Soldier-CATT appears to be a leader trainer, e.g., where the platoon leader leads and controls his actual squad leaders, but the squad leaders control simulated squad members.

field smells in the training environment (e.g., diesel fumes, burning oil, wood smoke, cordite)."[19]

Also at issue is the full physical fidelity of the user experience as a dismounted soldier in the squad training. There are constraints on the physical movement and use of concealment that are key to dismounted maneuver. Soldiers do not physically run through the environments. Instead, they will move via an interface, by, for example, using buttons on the forward grip of their M16.

Credibly simulating the physical details of combat in MOUT and close-combat environments for dismounted combat also poses problems. For example, there must be abilities to simulate creation of mouse holes in every dimension of buildings, to provide appropriate shoot-through capabilities to vegetation, floors, and room dividers, and to use different methods/materials to build strong points inside rooms.[20] Some of these offer challenges at the fine grain size needed to provide appropriate realism to urban combat. These do not seem insurmountable, but will require extensive developmental efforts.

The challenges to developing intelligent SAF for Soldier-CATT are the same as for those described earlier for OneSAF. The promise of delivering sophisticated, easy-to-use scenario development, including vignettes and AAR tools (including automated AARs), is not likely to be achieved in this timeframe, based on attempts to date and the level of importance that is assigned to these tasks.

Despite these constraining issues, we think that, assuming sufficient funding (see discussion below), Soldier-CATT squad virtual trainers are likely to advance considerably past the current capabilities of the current Engagement Skills Trainers (EST) by 2016. The feedback we have had from unit trainers has been that the EST has been a valuable enabler, given the COE both for training marksmanship, "shoot/don't shoot" decisions, and other tactical skills. While many aspects of full physical realism (e.g., movement, physical contact between soldiers in MOUT scenarios) will likely continue to limit training benefit, these

[19] System Level Requirement 4.1.1.1.2.2.12.

[20] An example raised was using a box spring stripped of fabric and padding to cover an open window that would allow sight and shots out but keep grenades out.

types of trainers have the potential to supplement live training in many important areas. For example, in virtual MOUT training, the effects of using demolition devices and other explosive effects can be seen to a far greater degree than in an equivalent force-on-force training event, whether live or Force on Target.

The degree to which these squad-type virtual trainers obtain this potential will largely depend on the funding placed into improved EST and Soldier-CATT development. There are significant costs associated with even the relatively simple "vignette approach" of EST, and development of more interactive SAF approaches will be far more costly. This issue, as well as the limited progress in demonstrating the measurable value of such training capabilities, leads to the conservative estimates of the capabilities that will actually be achieved in the 2016 timeframe.

Multi-Echelon Collective Skills Virtual Simulations Trainers

In this section we assess the planned enhancements to improve the capability of virtual simulations to support platoon-and-above training for FCS units. The plans for FCS unit training envision embedding a CCTT-like capability in the FCS vehicles. We will discuss the potential for embedding this type of virtual training in Chapter Nine; here, we will focus on the likely intrinsic potential of collective virtual simulations trainers.

As discussed earlier in this chapter, the Army's current virtual training capability for collective training is the CCTT. Strictly speaking, CCTT is not a pure virtual simulation, in that only combat vehicle crews and a modest number of dismounted infantrymen participate using simulated equipment. The other friendly, enemy, and noncombatant elements are replicated by soldiers on constructive simulation workstations using SAF.

The CCTT has proved to be a highly effective means of training unit-level, vehicle-based combat in open terrain. However, its capability for training units for other types of operations, such as supporting infantry in MOUT operations, has been limited. A main constraint has been the inability to realistically replicate close-combat operations involving friendly and enemy dismounted elements.

The planned enhancement of multi-echelon virtual collective training involves three main components: improvements to CCTT, integration with Soldier-CATT squad and leader trainers, and use of OneSAF to improve CCTT's constructive capability.

The CCTT requirements contain a number of important "pre-planned product improvements," or P3Is.[21] The funding status of P3Is is unclear.

There is ample reason to believe that in the 2016 time period there will be benefits to CCTT in the areas of improved modeling of the physical environments (MOUT, weapons effects, weather, obscurants, sensors) and the addition of different vehicle types, sensor systems, and weapon types that will help CCTT maintain its role as a training system for the future BCT. These are not areas that require significant research or deep development efforts; improvements in these areas will benefit training for some COE environments and new threats, but will not otherwise significantly improve the quality of training. Nor will these improvements significantly decrease the need for skilled human scenario authors, OCs, SAF operators, and AAR developers.

The likely benefits from enhancement to CCTT through 2016 are mixed. There will not be significantly greater physical fidelity (e.g., rotating turret or simulated movement of vehicle) in the simulators over what is in the current CCTT. There are clear plans to include more soldier modules and dismounted soldiers in the CCTT environment, including the squad and leader Soldier-CATT trainers, but the effectiveness of the squad CATT as a significant enhancement will be limited by the small number of soldier modules for human dismount play.

There are possible applications of integration of squad soldier CATT and combat vehicle virtual trainers. Indeed, there are current convoy virtual trainers that effectively leverage EST and CCTT technologies. But the potential for virtual training of a large number of

[21] Pre-Planned Product Improvement: "Designed-in provision for future enhancement. This may require the initial version to have excess capability to accommodate later enhancement."

actual dismounted soldiers is limited, and the reasonable potential is for training smaller units, e.g., a squad and one or two combat vehicles.

For company-and-above combined arms training events, the key enhancement to allow better integration of dismounted and mounted elements in operations will be the Soldier-CATT leader trainers, in which leaders on workstations or their equivalents control dismounted SAF soldier elements. The key to this capability in the future will be OneSAF, which would provide the underlying SAF behaviors. OneSAF will also be key to expanding the realism of the other constructive elements in future CCTT-type trainers.

As detailed in the earlier review of OneSAF in the constructive training section, CCTT SAF will have very limited improvements in intelligent behaviors in the 2016 timeframe; the level of sophistication/complexity in behavior delivered in real time from multiple entities will remain very limited. This is due primarily to the need to understand how to represent the complex spatial and temporal reasoning required for even moderately complex SAF behaviors. And even when those capabilities are achieved beyond the 2016 timeframe, there will still be a need for significant investments in "knowledge engineering" with highly skilled SMEs to develop a reasonably complex set of behaviors that are realistic.

There is mention in the CDR of improving ease of use and adding power to the scenario-authoring and AAR tools. However, convincing evidence is lacking from the history of CCTT development or other military simulations development to suggest that there will be significant gains made in these areas that will lead either to significant time savings by simulation center staff or to an ability to make such tools usable by lower-skilled individuals. The promise of delivering sophisticated, easy-to-use scenario-development and AAR tools (including automated AARs) is not likely to be achieved in this timeframe, based on attempts to date and level of importance that is assigned to these tasks. Building scenarios and developing and delivering AARs will continue to be skill-intensive activities carried out by highly skilled trainers.

Conclusions

Table 7.1 provides a summary of the enhanced capabilities, likely benefits of enhancements, and limiting factors for the different types of virtual simulation-based training in the 2016 timeframe. Following the table, likely quality, quantity, and adaptability benefits are discussed by type of virtual trainer.

Table 7.1
Virtual Simulations: Likely Benefits and Limiting Factors

Enhanced Capability	Likely Benefits of Enhancement	Limiting Factors
Soldier/Operator/ Maintainer Skills, e.g., trainers for vehicle drivers, UAV/UGV operators, equipment maintainers, Tactical Language Trainer	Compared to live • More iterations in given time • No maneuver/gunnery area constraints • Reduced OPTEMPO costs • Facilitates decentralized, individual training • Greater range of tasks/ conditions	• Limited physical fidelity • Unknown transfer from virtual to live/ actual • Some funding risk
Crew/Squad Skills, e.g., Engagement Skills Trainers for fire squads/fire teams, COFT, CONVOY Trainer, Squad Soldier-CATT	• More iterations in given time • No maneuver/gunnery area constraints • Greater range of tasks/ conditions	• Limited physical fidelity • Cost of technical and content development and equipment procurement • Funding risk for training develoment. (e.g., scenarios) • Limited detail in KPP specifications • Difficulty of COE
Multi-Echelon Collective Skills, e.g., CCTT, Soldier-CATT at platoon/company level	• Same as first, except no decentralization of individualized training • Improvement of basic CCTT capabilities • Better integrated play of leader C2 for armor and dismounts	• Limited dismount and COE replication • Cost of technical and content development and equipment procurement • Realism risk from reliance from OneSAF and SE Core • High risk of ET

Virtual Soldier/Operator/Maintainer Skills Trainers. Overall, this category of virtual trainers has large potential to improve the quantity of training, and also some potential to increase the quality of training. The technology available in the 2016 timeframe should allow for effective training of operator and maintainer skills, especially for C4ISR precision fire systems, which are at the heart of advanced FCS operational effectiveness capabilities. The inclusion of the requirement to develop these types of trainers in the FCS operational requirements documents means that these trainers will be funded out of material development funds, and this increases confidence that such trainers will be widespread and capable.

However, a significant limitation on training "walk"- and "run"-level training for some vehicle operators will be the lack of realistic motion needed for effective training on some types of equipment (e.g., for driver training).

Although there will be benefit in some areas (e.g., language training), overall individual virtual enhancements will do little to directly improve the adaptability of training to COE conditions. In this regard, funding will almost certainly constrain the amount of content that can be developed for soldier and leader type knowledge and application skills.

Virtual Enhancements for Crew/Squad Skills Trainers. The crew training systems share many of the likely capabilities and constraints of the virtual operator type trainers. They will similarly offer great potential to improve the quality and quantity, if not adaptability, of crew training. Indeed, given the increased capabilities and ammunition costs of FCS weapon systems, the relative role of virtual trainers as an alternative to live-fire training will likely be far greater than it is today.

However, caution is warranted in the case of Soldier-CATT at the squad level. With regard to quality improvements, given the limited physical fidelity of individual movement when applying Soldier-CATT at the squad level, this trainer will have less likely benefit than vehicle-based crew trainers like COFT and Convoy Trainer. Moreover, given the current lack of demonstrated training benefit and likely continued high costs of this type of virtual trainer, funding risk is likely to be substantial.

Virtual Enhancements for Multi-Echelon Collective Skills. The CCTT and enhancements will continue to provide state-of-the-art virtual training for collective skills surrounding vehicle-on-vehicle combat for armor and IFVs at the company level and below. However, the ability of CCTT and Soldier-CATT leader trainers to effectively evolve to provide an affordable capability to train under COE conditions is an area of risk, and is reliant on effective OneSAF development. As discussed in the previous chapter, the limited likely advances in AI for SAF and advanced training tools will all limit likely benefits of this type of virtual trainer without the benefits of skilled training support manpower.

In sum, virtual trainers have potential to improve in their ability to replicate vehicles, weapons, weapons effects, terrain, and other physical attributes of the environment (and thus improve training quality). However, their increased effectiveness in providing significantly more training exercises or better adapted training exercises above crew level is questionable, relative to current levels of usage.

CHAPTER EIGHT

Assessment of Planned Enhancements for Simulation-Based Leader Tactical Skills Training

In this chapter we review simulations that have as their goal the training of tactical skills to individual or small groups of Army leaders. This is separate from the goal of the simulation-based training events and constructive tools, which are used to train groups on command and battle staff skills. Here we focus on Leader Tactical Skills Training Simulations (LTSTSs) that can be delivered via standard commercial personal computers, including laptop computers. Such simulations developed or modified specifically for training applications are being called "serious games"[1] and are of growing interest to the training community. More broadly, serious games focus on uses of gaming technologies applied to education, training, health, and public policy. Some call these simulations "laptop trainers" because they run on affordable laptop computers without ancillary hardware. This name also conveys the "anytime, anywhere" nature of their deployability and the low overhead of support needed for their use.

This category of LTSTSs includes both constructive (e.g., Tactical Operations Simulation,[2] or TACOPS) and virtual (e.g., Full Spectrum Command[3]) simulations, categories of simulations that are often blurred. Traditionally, the visual displays of constructive simulations have provided a "bird's-eye view" of unit icons moving on maps. This

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1 www.seriousgames.org

2 http://www.battlefront.com/products/tacops4/tacops4.html

3 www.ict.usc.edu

type of visualization can support the learning of tactics by allowing the trainee to watch his or her plans unfold over time, while also potentially watching the execution of opponents' plans. Such simulations could not recreate the first-person perspective of an individual in combat, however, and therefore were less effective in training certain kinds of individual leader skills, including situational awareness.

In contrast, with Full Spectrum Command and commercial games such as the WWII Battlefront series[4] of games, the user can move from "bird's eye" to "first person" views and 3D sound effects to allow auditory localization of events. This experience of first-person visual and sound has been characteristic of "virtual simulations."

The perceived training value of such serious games has led Army training developers to place increased focus on LTSTSs. Because these tools have been identified for enhancement, we found it useful to jointly discuss relevant virtual and constructive simulations used for this purpose.

Current Capabilities and Challenges of Leader Tactical Skills Training Simulations

LTSTSs in the military training R&D community are characterized by direct interaction between the learner and the simulations. This direct interaction means that there is little labor and preparation overhead involved in using these simulations. However, because LTSTSs do not use Army equipment as interfaces (instead, they use keyboards, mice, and sometimes game controllers), they currently provide less battlefield realism than simulators. LTSTSs are currently available primarily as commercially developed "serious games" such as TacOps, America's Army, and Full Spectrum Warrior.[5]

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[4] www.battlefront.com

[5] Full Spectrum Warrior is an Xbox game, and America's Army is a PC-based game, soon to be released for the Xbox console.

These simulations typically focus on "Leader Skills" at the crawl and walk level, have much smaller training audiences, and have very lean support. Examples of the kinds of skills trained include:

- A company commander, his platoon leaders, and FIST Chief plan and execute an assault on a MOUT site using Full Spectrum Command.
- A battalion commander and his S3, FSO, and company commanders simulate a battalion, planning and executing an armor assault via TacOps, a laptop, platoon-level simulation that looks like a map exercise.[6]
- A group of captains explores different approaches to a BCT tactical problem via TacOps with different methods to explore different possible outcomes.

Current challenges to LTSTSs for training overlap with those identified for traditional constructive command and battle staff training. These include:

- Limited physical realism for MOUT and COE training due to constraints on how the underlying simulation models represent buildings, underground passages, and weapons effects, among other important entities and effects.
- Limited realism in SAF behavior (both BLUFOR and OPFOR), including movement rates, concealment/visibility, primitive nature of behaviors.
- Unknown transfer from simulation-based training to actual expertise and possible negative training, i.e., acquisition of skills and knowledge that do not map onto actual, needed skills/knowledge and are detrimental to soldier or unit behavior.[7]

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[6] Michael Peck, "Training from a Hobby: Computer Game Transforms into International Tactical Simulation," 24 October 2005, *Training and Simulation Journal.* http://tsj.dnmediagroup.com/story.php?F=1043791

[7] In the case of first-person simulations this includes aspects of play that are not realistic, such as how concealment is modeled, having only three positions a player can assume (stand-

- Lack of current procedures and online repositories to effectively share scenarios and training "lessons learned."
- Very limited feedback to learners from the simulations, tutorials, and automated AARs.

These challenges are similar to those faced by constructive simulations designed to support battle command training. However, given that there will be fewer instructors or training staff members involved in LTSTS-based training, some of these challenges could potentially impact even more heavily on LTSTSs. Perhaps not surprisingly, most tests and uses of the LTSTSs have been in institutional settings where experienced small group instructors use them as educational tools.

However, one reason for discussing LTSTSs separately from other constructive and virtual simulations is that these training devices offer several potential advantages for future leader training:

- The training has lower overhead than constructive simulation-based training for command and battle staff skill and than some virtual training, such as CCTT. Specialized staff is not needed to prepare, set up, and run the training events.
- These simulations make it easy for students to get feedback directly from the simulation outcomes and opponent (although feedback directly from an OC or SME is clearly more effective and desired by soldiers, when possible).[8]
- Current and future applications of this type can be more easily adapted to the specific needs of individual students, whether through the use of replay features and even limited scenario authoring tools in some cases.
- These trainers require no specialized equipment or deep knowledge to use and hence are able to provide limited training "anytime, anywhere."

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ing, crouching, and lying down), and weapons effects that are not realistic, such as creating mouse holes in three dimensions in structures during urban operations.

[8] S. Beal, *Using Games for Training Dismounted Light Infantry Leaders: Emergent Questions and Lessons Learned,* U.S. Army Research Institute for the Behavioral and Social Sciences, Research Report 1841, September 2005.

In other words, although simulations for Leader Tactical Skills Training cannot overcome the shortcomings of constructive training more generally, their relative ease of use and the particular skills they are designed to train could make them an attractive option. Given the potential value of these tools, and in partial response to the challenges identified above, the Army and the commercial gaming industry are developing different aspects of such simulations to improve their potential as effective trainers. These enhancements and their likely benefits and limits are discussed next.

Proposed Enhancements to Simulation-Based Leader Tactical Skills Training, Likely Benefits, and Limiting Factors

While there is not a formal program for advancing this category of training enhancement, we will make some projections of its future improvements (by 2016) based upon ongoing achievements and the direction of emerging technologies.

Improved Realism in Some Areas. Improving realism in LTSTSs is a need recognized in both the Army training development community and the commercial game development market.

Visual realism in games has continued to improve, taking advantage of the steady increase in computational power of PCs and rendering power of PC graphics cards. The same improvements are being seen in games for game consoles (e.g., Sony Playstation 3, Xbox 360, Nintendo GameCube). The game industry has developed the visual quality of games to very high levels,[9] so visual realism will lose value as a competitive advantage in the near future and be common in games in the 2016 timeframe. Hence, LTSTSs will also benefit from increased visual realism in this timeframe.

[9] The level of visual quality in some current games allows a player to lie in tall grass for concealment and watch the grass wave in the wind as the shadows from the overhead leaves move across the terrain.

There will also be significant improvements in the simulations' ability to recreate the realism of the physical environment. The increased computational power that will continue to come to market in future PCs will allow better modeling of materials and surfaces to produce "dynamic terrain" that easily changes to produce shell holes in the ground, blow mouse holes through walls, dig fighting positions, and create other effects.

Improved Ease of Use and Modification Tools Will Provide Lower Training Support Overhead and Large Scenario Libraries. In terms of improving the adaptability of training via serious games, there is an important precedent in the commercial gaming community for developing libraries of modifications for games (e.g., scenarios, terrain) to share within communities of gamers via publicly released "software development kits," also known as modification toolkits, or simply "modding tools." Hence, if modification tools for these LTSTSs are released, there should be large improvements in access to web-based repositories of scenarios. These will be developed both by Army training personnel as well as hobbyists.

In some areas, however, we see limited likely improvement:

Limited Improvement in SAF Realism. One area of realism and adaptability that will not experience great improvement in the 2016 timeframe is the intelligence of SAF, which will continue to be relatively primitive. SAF will not be able to independently provide challenging play to human opponents in real time. The reasons for this limited enhancement are cited in the previous section on constructive simulations.

Unknown Training Transfer Will Limit Development. Questions about transfer of the training in LTSTSs (both positive and negative training) will continue until there is a body of research that demonstrates where and how positive and negative learning occurs.[10] This research should include the specific tasks and skills that are reasonable

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[10] Work such as that of Beal out of ARI, referenced earlier, is representative of the type of research needed to inform questions regarding training transfer and, eventually, return on investment.

targets for this type of training media. Such research should be a priority for Army and academic researchers.

Limited Improvements in Tools from AI. There will be limited improvements to automated feedback in the form of AARs or tutorial guidance to learners during a simulation run in the 2016 timeframe. LTSTSs will include AI-based basic evaluation at the "crawl" level after methods for integrating such feedback[11] have moved into more common usage by the end of the 2016 timeframe, and as the processing power of PCs increases and tutorial methods mature. However, this type of guidance will not be sufficient to provide walk-level feedback from training.

Limited Funding for Development. LTSTSs currently are not funded through traditional Army simulation-development channels. They have arisen either through institutional initiatives or via research efforts. The Army should consider systemic funding to develop, study, and evaluate this class of low-cost but limited training technologies.

Conclusions

Our conclusions regarding the potential of serious games for training leader tactical skills are summarized in Table 8.1.

Enhancements to LTSTSs offer opportunities to increase the quantity of training for leaders. The heavy participation from the commercial sector to improve ease of use and tool sets, combined with the lower need for training support and the ability to more easily adapt these games and create scenario libraries, should lead to significant increases in the quantity of training events for tactical leader skills in the 2016 timeframe.

These enhancements offer limited opportunity for improved quality in LTSTSs. While the increased realism in the visual and physical simulations should provide higher quality of training in the 2016

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[11] Simple tutorial knowledge in the form of basic feedback on simple actions is currently being marketed for Army simulations running on PCs by Stottler Henke, Inc. As of July 26, 2007:
www.stottlerhenke.com.

Table 8.1
Serious Games for Leader Tactical Skill Training: Likely Benefits and Limiting Factors

Enhanced Capability	Likely Benefits of Enhancement	Limiting Factors
Leader Tactical Skills Training Simulations, e.g., individual or small group trainers such as TACOPS or Full Spectrum Command	• Improved quality via improved visual and physical simulations of environments • As usability and tools improve, lower need for external support to set up and run • Libraries of scenarios developed via modification tools	• Limited realism from SAF • Funding for development • Possible negative training transfer for some skills and tasks • Difficulty providing feedback to learner above "crawl/walk" level due to limits on AI

timeframe, overall increases in quality will not be significant due to limited likely improvements in SAF and AI-based feedback to learners. Overall quality of the training provided by LTSTSs will continue to be an issue until more research into the positive and negative aspects of such training is carried out. There will also continue to be a need for expert human input for aspects of training/AARs to get the most value from such training.

These enhancements offer some potential of improved adaptability. It is common in the commercial gaming community to develop and distribute modification tools during a game's lifecycle. This allows game users with limited technical skill to modify scenarios and create online libraries of these scenarios. If LTSTSs became a formal development program, a similar approach might be cost-effective for developing curricula for LTSTSs. To ensure appropriate content and positive training transfer, TRADOC SMEs would still need to play important quality assurance roles in evaluating such curricula. If successful, such an approach could increase the adaptability of this enhancement in the 2016 timeframe.

While we have made conservative estimates of their benefits, our overall conclusion is that LTSTSs offer considerable potential to provide low-cost, low-overhead, reasonable-benefit future training tools to teach at least crawl, and possibly higher-level skills, to Army leaders at many levels. Given current applications and the increasing complexity of battle command at battalion and above, the largest potential may be for training tactical skills at company and below, but wider application is certainly possible. However, benefits in the 2016 timeframe will be realized only if their development is supported and if they are developed with appropriate input from Army SMEs and expert trainers.

CHAPTER NINE

Assessment of Integrating Enhancements

In this chapter we focus on three enhancements that do not directly supply operational training but rather provide critical support for that training. These are the Live-Virtual-Constructive Integrated Architecture (LVC-IA), Embedded Training (ET), and Training Manpower Support for Home Station. These enhancements support both live training and simulation-supported training. Each enhancement is defined in detail at the start of its corresponding section below.

For each enhancement, we assess current capabilities and challenges as well as proposed improvements to those capabilities and their associated challenges in the 2016 timeframe. We also draw some conclusions about the potential future effect of these enhancements on the quality of training, the number and duration of training events, and the adaptability of training events to COE requirements.

Integration of Live, Virtual, and Constructive Simulation-Supported Training

In this section we assess LVC "architectural" integration and the "common training tools" that are a key component of various LVC-IA initiatives.

In the area of architectural integration, we review the Army's overall LVC-IA[1] effort and underlying architectures to support integration

[1] Initial Capabilities Document for Live, Virtual, Constructive–Integrating Architecture (LVC-IA) and Infrastructure, Version 2.2, July 2005.

within and across live, virtual, and constructive simulation-based training systems and operational C4ISR systems. These are the Joint Land Component Constructive Training Capability (JLCCTC),[2] Common Training Instrumentation Architecture (CTIA),[3] Live Training Transformation (LT2),[4] and Synthetic Environment Core (SE Core).[5]

In the area of training tools, there are a number of proposed efforts to develop common tools to support training. These include tools for scenario authoring/management, exercise management, data logging, AAR analysis, student performance tracking, and training data management. The most ambitious effort at developing common training support tools across simulations is the FCS's Training Common Components (TCC)[6] program. However, there have also been many separate requirements in training systems' ORDs to develop subsets of these tools, including requirements in JLCCTC, CTIA, and SOE, as well as within various constructive and virtual simulations program initiatives discussed in previous chapters. Efforts to build common tools will be reviewed following the review of integrating architectures.

Integrating Architectures: Current Capabilities and Challenges

The DoD's strategic goals for Training Transformation (T2) recognize the need to integrate different types of training to meet readiness needs. The goals recommend that trainers "develop a robust, networked, *Live, Virtual,* and *Constructive* training and mission rehearsal environment."[7] The promise of being able to integrate different combi-

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2 Previously the Army Constructive Training Federation (ACTF).

3 The Green Guide to Common Training Instrumentation Architecture (CTIA): A Key Component of the Army's Live Training Transformation (LT2) Strategy, 12 January 2004.

4 Initial Capabilities Document (ICD) for Live Training Transformation–Family of Training Systems (LT2-FTS). Final Draft Version 2.0, 22 February 2005.

5 Operational Requirements Document for Synthetic Environment (SE) Core, Approved February 2005.

6 http://www.peostri.army.mil/PM-FF/Components.jsp

7 Department of Defense, *Strategic Plan for Transforming DOD Training,* March 1, 2002, p. ES-27.

nations of live, virtual, and constructive simulations into operational C4ISR systems to improve the quality of training for units is extremely alluring.

Although current capabilities for integrating LVC training are limited, live, constructive, and virtual simulation and operational C4ISR systems have been regularly integrated for some time in a limited number of settings. For example:

- At the NTC, artillery is played constructively and UAVs are virtually played into the live training events. These and other simulation integration of capabilities provide wrap-around of OPFOR and BLUFOR units.[8] This integration takes place via the Digital Battlestaff Sustainment Trainer (DBST).[9]
- In CCTT training events, artillery and dismounted infantry are played constructively while tanks and BFV crews participate virtually.
- In constructive simulation exercises at Fort Hood and Fort Lewis, operational C4 systems in tactical command posts (CPs) have been "stimulated" by constructive simulations through DBST.

Additionally, there have been several major joint exercises and technical demonstrations to show the potential of high levels of LVC-IA. These include the Army Transformation Experiment 2002, or "Millennium Challenge 02"[10] and studies at the Unit of Action Maneuver Battle Laboratory (UAMBL). However, while these events have dem-

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8 This "wrap-around" of live simulation-based training with constructive- and virtual-simulation-based elements at the NTC reportedly requires approximately 30 contractors. (Source: communication with personnel who formally execute this support, June 2006.)

9 DBST combines the outputs from a federation of live, constructive, and virtual simulations to be transmitted through simulations-to-tactical translators to provide "stimulation" to the ABCS and other C4ISR systems. This provides the commander and battle staff with the ability to track the battle and provide command and control to simulated units using their organic information systems. As of July 26, 2007:
http://www.msrr.army.mil/index.cfm?RID=MNS_A_1000903

10 For information about Millennium Challenge 02 and the Army Transformation Experiment 2002, see the Web site below. As of July 26, 2007:
http://www.jfcom.mil/about/experiments/mc02.htm

onstrated some integration of capabilities, they have also required great amounts of special preparation and support to carry out.

Moreover, the actual levels of integration of virtual into live unit play have been limited because of the inherent lack of realism of having a virtual system engage a live soldier or crew who cannot hear, see, or counter the virtual system.

There are several current challenges to integration of live, virtual, and constructive simulation-based training events:

- Previous attempts to integrate legacy simulations of a single type (constructive, virtual, or live) provide informal evidence that such integration poses significant technical challenges.
- Attempts to integrate different types of simulations suggest that cross-type integration is also technically difficult and frequently results in lost training time due to technical problems.
- Extensive scheduling, preparation, and support are needed to execute effective integrated events.
- The quantitative training benefits to the different organizations being integrated are unknown, as are the costs of that integration.
- There are large areas of uncertainty regarding the technical aspects of achieving interoperability between legacy and newly developed simulations, or components of simulations (e.g., SAF).[11]

The magnitude of these current challenges with respect to integrating live, virtual, and constructive simulations and C4ISR systems for training suggest that the Army should make generally conservative estimates of what can be achieved in the 2016 timeframe.

Integrating Architectures: Proposed Enhancements, Limiting Factors, and Likely Benefits

Proposed Enhancements. LVC-IA is the Army's overarching initiative to integrate future live, virtual, and constructive simulations

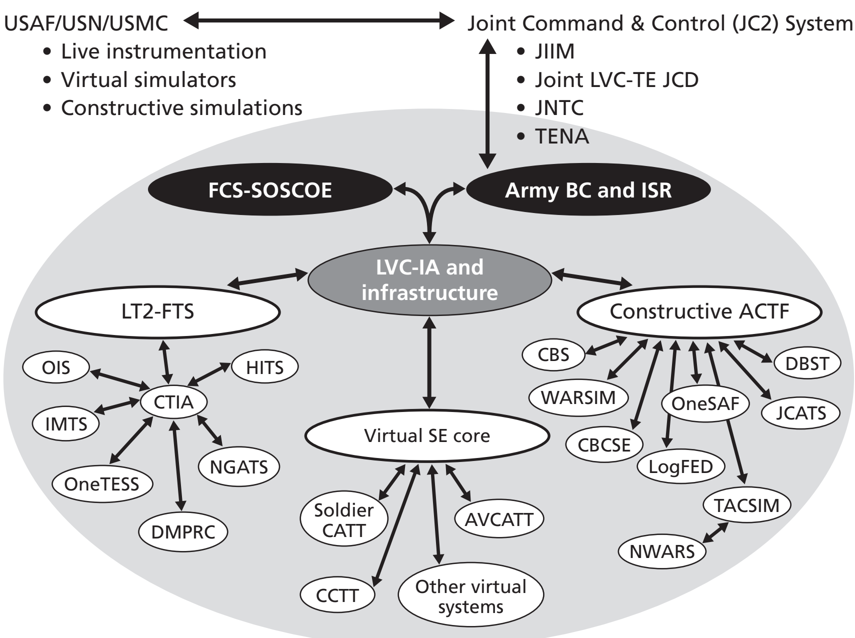
[11] P. Davis and R.H. Anderson, *Improving the Composability of Department of Defense Models and Simulations,* Santa Monica, CA: RAND Corporation, MG-101-OSD, 2003.

with operational C4ISR systems to support future training events as well as mission rehearsal type activities. Figure 9.1 from the LVC-IA Initial Capabilities Document (ICD) shows both how the LVC-IA fits into the different types of Army simulation-based training and how other integration efforts reviewed in this section fit in.

Three major components of the LVC-IA are JLCCTC, LT2/CTIA, and SE Core.

JLCCTC. As discussed earlier in this document, current constructive simulations being regularly used for Army training are part of what was until recently the Army Constructive Training Federation (ACTF) and is now called the Joint Land Component Constructive Training Capability (JLCCTC). The goal of JLCCTC is to provide

Figure 9.1
The LVC-IA Operational View



RAND *MG538-9.1*

a federation[12] of eight models that can interoperate in the short term, while migrating over the long term to an objective system with fewer simulations that are more highly integrated and use less communications bandwidth.[13]

LT2 and CTIA. The Live Training Transformation, or LT2,[14] is the Army's initiative to develop a set of integrated live training products that provide the "live" piece of the LVC-IA infrastructure.[15] The Common Training Instrumentation Architecture (CTIA) is part of the LT2 program that has the goal of providing a set of guidelines, standards, and specifications for Army-wide training instrumentation systems (e.g., maneuver CTCs, home station, digital ranges, FCS-equipped BCT sites) that will allow live simulations to be integrated with each other and live training to be integrated with virtual and constructive training.

CTIA is a "product line architecture that will implement the U.S. Army's Live Training Transformation (LT2) and leverage the high degree of commonality of requirements among the U.S. Army's instrumented ranges and home stations." [16] This common architecture seeks to improve training quality and also reduce the costs of development, logistics, training, and maintenance through a technical approach that is a "component-based, client-server architecture" that allows LT2 products and components (e.g., HITS, NTC-OIS, OneTESS) to interact and share data freely.

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[12] The JLCCTC federation of constructive models uses the High Level Architecture (HLA) that the DoD is developing to let simulations interact instead of the older Distributed Interactive Simulation (DIS) protocols to get better performance. HLA requires smaller amounts of information to be moved on networks to keep entities aware of each other.

[13] The type of inter-simulation interaction in JLCCTF is via a "publish and subscribe" model or "PUB-SUB," where pieces of a federation publish their results on a server and other members of the federation "subscribe" or get the information from that server.

[14] Initial Capabilities Document (ICD) for Live Training Transformation–Family of Training Systems (LT2-FTS), Final Draft Version 2.0, 22 February 2005.

[15] P. Dumanoir and J. Rivera, "Live Training Transformation (LT2)–A Strategy for Future Army and Joint Live Training," Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC), Paper no. 1982, Draft Version 8b, 2005.

[16] https://ssl.peostri.army.mil/CTIAPortalCMS/public/ctia_faq.html

While such integration of different live simulation systems (i.e., different types of FOF and FOT) is currently a technically challenging task, there will be probably be good progress in this area in the 2010–2016 timeframe. These improvements will likely increase the quality of training events by facilitating more complete feedback (e.g., detailed tracking of shooter-target engagements, both FOT and FOF). However, none of the proposed LT2 or CTIA capabilities would directly lead to increased quantity of adaptability of live training events, since they would not decrease the time needed for an event nor provide for an expanded range of conditions.

SE Core. The Synthetic Environment (SE) Core's mission is to provide a common environment for virtual simulations by linking all current and future virtual simulations into fully integrated virtual simulation architecture.[17] SE Core will integrate "standard visual models" (representations of objects in various states such as operational, damaged, and destroyed as viewed via visual, IR, and Night Vision), Objective OneSAF System (OOS) for a standard SAF, standard rapid terrain database (TDB) generation, a "master TDB open format," dynamic terrain (terrain that can be modified by actions of weapons or equipment, e.g., blowing holes in walls or bulldozing fighting positions), atmospheric effects, "Chemical, Biological, Radiological, Nuclear, and High Explosive (CBRNE) effects," and integrated AAR. Also included in the ORD are specific goals for simulating COE and MOUT operations.

The movement toward standardization of many aspects of virtual simulations to provide integration is an appropriate goal. However, the same critique regarding the large magnitude of the challenge of providing such "seamless integration" must be restated: Achieving interoperability of simulations is a very difficult task, particularly with legacy systems. In the 2016 timeframe it would be prudent to conservatively estimate that there will be progress in rapid terrain database development, standard visual models, and some integration of the SAF

[17] Operational Requirements Document for Synthetic Environment (SE) Core, Approved February 2005.

from OneSAF.[18] There will surely be significant progress in deploying more dynamic terrain, but the achievable levels of this dynamism are unknown at this time.

So the quality of integrated virtual simulation-based training (CCTT, CATT, AVCATT) will go up significantly in the 2016 time-frame. There will be improved realism and better integration of dismounted play with vehicle and airframe-based simulator training. However, on the whole, proposed SE Core capabilities would not directly improve the quantity or adaptability of these integrated events.

The LVC-IA effort[19] has been defined to have four required capabilities with subcapabilities:

1. Integrating Architecture
   - Integrate *live* instrumentation systems, *virtual* simulators, and *constructive* simulations
   - Use "a set of protocols, specifications, and standards that support the operation of a seamless and integrated LVC environment where hardware, software, network components, and modules are interoperable with other systems"
2. Operational System Stimulation
   - Stimulate and simulate Army, Joint, and other Services' Battle Command Systems (BCS)
   - Apply across LVC
3. Plug and Train
   - Provide a holistic, simulated training environment available anywhere, anytime
   - Include data collection and AAR tools as well as exercise preparation and control tools
4. Sustainment
   - Sustain the technical architecture and infrastructure

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18 However, as mentioned in the discussion of OneSAF, the "intelligence" of the integrated SAF behaviors will most likely remain low.

19 Initial Capabilities Document for Live, Virtual, Constructive–Integrating Architecture (LVC-IA) and Infrastructure, Version 2.2, July 2005.

LVC-IA must provide these capabilities for current (legacy) and future simulation systems.[20]

Limiting Factors and Likely Benefits. As earlier analyses have documented,[21] providing interoperability between any complex set of information systems is a challenging task, even when those systems were originally specified to interoperate. Providing interoperability for legacy systems is even more challenging. The very large task that the LVC-IA effort has taken on is necessary but has many areas of known difficulty and risk. Because there appears to be some technical risk to achieving interoperability in the 2016 timeframe, it will be important to ensure that developmental programs are executed in a manner so that interoperability is designed into the training simulations and operational systems from the onset.

To the degree it is successful, LVC-IA has some potential benefits for improving training realism.

- Units conducting battle command training could, as standard training practice, use their organic C4ISR equipment while training using simulations.[22]
- Easily integrated virtual and constructive simulation-based training through operational C4ISR systems is clearly important to constructively supported battle command training, as it will allow realistic visual ISR feeds (e.g., from UAVs) to operational command and control systems.
- LVC-IA can help create a more realistic training experience by providing easier constructive "wrap-around" of other friendly, enemy, and noncombatant elements and events for a live battalion exercise without their actual live participation. This would allow a "live training" company training to engage a live enemy, while "seeing" the overall BCT operation FCS C4 systems, and

[20] Slides presented at an LVC-Integration Architecture meeting at PEO STRI, run by LTC Carson, April 2005.

[21] Davis and Anderson (2003).

[22] Note that DBST provides a current means to achieve this capability.

seeing and engaging constructive enemy "over the hill" using a virtual UAV.

LVC-IA could also facilitate more training benefit from current exercises. For example, a BCT (with subordinate battalion TOCs) could exercise in a more realistic JCATS-driven constructive battle within the framework of a division engaged in simulated play via WARSIM. As another example, LVC-IA can provide a brigade commander and staff with a realistic span of control by having one battalion in live training, and two battalions exercised in a constructive simulations environment.[23]

However, there are serious challenges to providing such opportunities for most aspects of live ground-unit operations to detect and engage virtual targets. Regardless of the number of types of simulations integrated through architectures, there will still be increased coordination challenges and costs of running integrated exercises. These costs must be carefully assessed relative to the training benefit that integration delivers in terms of training quantity (wider training audience) and quality (realism). Clearly, the more units participating and the more complex the exercise, the more demanding the planning and preparation for the event and the more costly it is to support. With units already lacking time for training (and its preparation) and being constrained by costs, there are pragmatic and time-cost reasons to believe that there will not be many additional training events that get carried out, even when LVC integration is more mature in the post-2016 timeframe. Thus, there do not appear to be large opportunities in the 2016 timeframe for three-way integration of live, virtual, and constructive training of ground maneuver units.

Integrated LVC Training Tools: Current Capabilities and Challenges

The value of having a common set of tools to support the different aspects of carrying out LVC training events—from planning through AAR—is clear and the prospect appealing. There would be decreased

[23] The JRTC has been doing something similar for years, having two battalions live and one simulated.

development and maintenance costs, as well as decreased training costs, if there were a single set of standard tools to support the following:

- Planning
- Scenario authoring/modification
- Exercise control (e.g., starting, stopping, resetting, and altering/adapting a simulations operation during a training event)
- Data logging (via automation and "smart" event tracking) and analysis for AARs
- Automated or semi-automated preparation of AAR materials.
- Presentation of AARs
- Recording and tracking of unit or individual performance and qualifications

Currently, the specifications for many simulation and integration efforts include examples of requirements for subsets of such tools. A number of tools have also been developed for individual simulation-based training systems.[24] However, it has not been the intent of such tools to operate with different simulations, and to date there has been no development of cross-simulation tools and little evidence of their actual benefit.

Integrated LVC Training Tools: Proposed Enhancements, Limiting Factors, and Likely Benefits

Proposed Enhancements. The requirements for a number of the architecture integration efforts and other live and simulation enhancements also contain specifications for some of these tools:

- **Training Common Components.** Training Common Components (TCCs) are a collection and integration of parts from other complex information technology development efforts including CTIA, OneSAF, and OneTESS. They are designed to sup-

[24] E.g., CCTT has the Commanders Integrated Training Tool (CITT) and the CCTT Exercise Initialization Tool (CEIT) to allow commanders to develop CCTT TSPs and many of the associated computer/simulation initialization packages required for a CCTT-based exercise. JCATS has authoring tool kits.

port ET in the FCS. The FCS Training Common Components (TCCFCS)[25] are an explicit effort to develop integrated tools that span the different types of simulation-based training. The TCCFCS are conceived to be a single set of tools that will operate with live, virtual, and constructive training for the FCS to support ET.[26] The goal of the TCCs is to achieve these common training support tools, in other words to create a "tool kit" mainly via reuse and rehosting of tools from contributing programs, specifically CTIA, OneSAF, and OneTESS. These training capabilities will be integrated with the FCS's System of Systems Common Operating Environment (SOSCOE).[27] These TCCs currently include a mix of training development/management functions and simulation capabilities.[28]

- Common training development/management functions include[29]
  - **Training Management.** "Provides user support for individual and unit training plan development and Training Support Package (TSP) management."
  - **Exercise Management.** "Provides user control and management of the selection, preparation, initialization, execution, monitoring, and termination of simulation based training exercises." This capability is planned to be initially provided primarily by CTIA.
  - **Scenario Development.** "Provides user with distributed scenario development capability for simulation based training exercises."

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25 Operational Requirements Document for the Future Combat Systems, UAMBL, Fort Knox, Change 3, 14 April 2003.

26 The FCS Training Common Components are co-managed by the FCS Training Program and PEO STRI's Project Office for Common Product Components (CPC).

27 Overview Briefing, Project Manager's Office, Future Force (Simulation), Cindy Harrison, January 2005.

28 The TCCs also include improved environmental representation and SAF capabilities which have been previously described.

29 Ibid.

   – **Data Logger.** "Provides data collection from simulation nodes for simulation based training exercises."
   – **After Action Reviews.** "Provides functionality to specify data collection, analyze simulation data, and prepare and conduct AARs."

- **JLCCTC.** Includes an associated set of software tools required to compose, initialize, operate, tune, and maintain a synthetic operational environment to support the conduct of collective command and staff training.
- **CTIA.** Includes the provision of a set of software tools to support live training event planning, preparation, and execution as well as for providing training feedback from those events.
- **SE Core.** Includes AAR tools.

Limiting Factors and Likely Benefits. The factors limiting the benefit of common tools for supporting live, virtual, and constructive simulation-based training events apply generally across the different categories of training support (e.g., tools for scenario authoring and AAR preparation). Therefore, we make observations about the limitations and likely benefits of these tools as a whole.

The benefits of common training tools for reducing the workload of planning, preparing, and executing training are obvious. This is especially true considering the increased need to integrate live, virtual, and constructive training to support FCS BCT training in the future. The real issue is the degree to which this workload will be reduced. The major issue is that these functions are currently highly complex and becoming more so given modernization and COE considerations. While improved common training tools will likely help, our overall conclusion is that the tools will help with more basic functions such as data collection rather than more complex functions such as analyzing data to determine how performance could be improved.

Examples of the types of complexity that make it difficult for tools alone to support training include:

- The complexity and specificity of different functions carried out by different types of units (e.g., engineer, light infantry, maintenance) and soldiers within those units (e.g., engineer commander, light infantry squad leader, FSB commander) do not argue for significant generality of function within analytic or automated AAR tools. Another example is the data needed to present the "what happened" in an AAR for a maneuver battalion TOC are considerably different from what would be needed for a Combat Trains Command Post or tank platoon in that same type of battalion. Hence AARs will still be largely driven by expert human input in the 2016 timeframe and will remain labor-intensive.
- There are also broad differences in types of scenario variables and entities, which does not suggest strong generality of tools for scenario authoring (e.g., scenarios and variables for a series of room-clearing exercises in Soldier-CATT are different from those needed for a company-level cordon-and-search for a live training operation compared to those needed for a CCTT-like scenario for armor-on-armor in open terrain compared to those needed for a WARSIM corps-level operation. The entities, constraints, and relationships that must be specified and arrayed for scenarios in each of these examples are very different.
- Because of the complexity in different types of entities, behaviors, and outcomes for the different areas of training, AI will provide only very limited additions to the functionality of tools in the 2016 timeframe. The state of the art is very limited in applying AI tasks such as evaluating the causality for combat outcomes that are beyond simple inferences.
- Appropriate metrics are lacking in key performance parameters (KPPs) and other aspects of requirements documents, which generally greatly underspecify the types of tools that are desired and the performance envelopes in which those tools should work.

The magnitude of these sets of challenges and the needs, in some cases, for basic research and development to assess the feasibility of some of the integration goals suggest wariness concerning possible improvements to the training systems that can be delivered to soldiers in the 2016 timeframe.

Conclusion

Table 9.1 summarizes the findings for the two types of LVC integration originally set out in this section: architectural integration and common tool integration. Based on these findings we make the following conclusions.

LVC-Architectural Integration will have some positive effects on the quality of training in the 2016 timeframe. To the degree that these architecture integration initiatives achieve their requirements, they have the potential to enhance the quality of live training by putting the training audience into a more complete and realistic operational setting than would be achievable in live alone. They can also allow fuller use of C4ISR systems during constructive-simulations-based battle command training events.

Table 9.1
LVC Integration

Enhanced Capability	Likely Benefits of Enhancement	Limiting Factors
LVC Integration, e.g., CTIA, LT2, LVC-IA, SE Core	• Constructive wrap-around to live • Simpler participation in higher/joint • Constructive wrap-around to virtual • Better virtual-constructive integration • Increased training audiences for live events	• Unknown cost-benefit to training • Unknown ability to get full interoperability • LVC manpower intensive for planning, preparation, execution compared to benefits
Tools to Support Training, some of Training Common Component (TCC): Scenario Authoring Exercise Management Data Logger AAR Capability	• Minimize duplication of "IA" tool development • Supports "best of breed" for common tools at basic level of tool productivity • Better standardization • Simplification to make trainers job easier	• Very limited contribution by AI • Complexity of functions across very different training demands makes generality of tools unlikely • Lack of metrics in KPP

LVC-IA will have limited effects on increasing the quantity and adaptability of training events. Success in integrating architectures also could provide increased adaptability of training events by providing a capability to execute more complex scenarios appropriate to the COE and by providing access to a wide variety of virtual and constructive scenarios, as well as variables within those scenarios, to help challenge forces engaged in live training.

However, integration of simulations and operational systems at the architectural level will come at a higher cost in terms of preparation time and support. And there are some technical risks in achieving the full requirement. Even if the technical challenges are overcome, resource constraints will likely limit the level of fielded capacity. Although such integration would help with quality, it will most likely not significantly reduce the need for training support manpower in the 2016 timeframe.

Improving tools to support training will reduce trainer workload, but it is unclear that this will yield significant improvements in quantity, quality, or adaptability, or reductions in training manpower requirements in the 2016 timeframe. Regarding integration of tools to support training across LVC application, the concept of reducing the number of disparate tools by building general tools or selecting "best of breed" tools is clearly attractive. However, there are no clear examples of analogous, general tools from other information technology application areas to suggest that this effort will have significant impact in the 2016 timeframe. To the contrary, developing such tools appears to require significant research on the limits of generality for specifying details of many aspects of training support tools.[30]

The effort required to achieve these goals appears to be great, and the benefits in the 2016 timeframe appear to be modest. To the extent that training tools provide easier feedback, trainers should be able to reduce the amount of data collection efforts. For example, increasing the level of information about performance of individual shooters

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[30] For example, specifying the data required and analysis needed for AARs to effectively train very diverse skills (e.g., AAR feedback for a platoon leader in a SOSO operation versus for an S4 in the battalion combat trains, versus for an Armor company commander in HIC).

should provide higher-quality tracking and feedback for live training. The likely beneficial effect is that trainers will be freed from mechanical functions and be able to focus more on complex and important training functions, thus increasing the quality of training.

Work in this area should be pursued, but we strongly caution against any optimism for significant reductions in manpower or broad improvements in overall simulation quality and adaptability to train soldiers before 2016.

Ongoing and proposed efforts to integrate different types of simulations (LVC) at the architectural and tool levels are appropriate courses of action that should be pursued. These development efforts will require strong leadership, significant funding commitments, and aggressive research and guidance concerning the tradeoffs of costs to develop and benefits of capabilities.

The magnitude of these integration efforts (number and complexity of legacy and new simulations and tool sets that must be integrated), the large number of unknown factors to achieve success, and the historical difficulties in integrating military simulations suggest generally conservative estimates of the success of integration efforts in the 2016 timeframe. As a result, broader, significant benefits are generally expected to improve the quality of training events, but not to significantly increase the number of training events, expand the number of soldiers or units receiving training, increase adaptability of training events through integration, or reduce manpower for training events.

Embedded Training

Current Capabilities and Challenges

Embedded Training (ET) is defined by TRADOC as "a capability built into or added onto operational equipment and systems. It enables training with soldiers using their own equipment while in the field or at home station."[31] A definition of embedded training provided by

31 *Embedded Training Concept,* TRADOC Pamphlet, 1996.

the Department of Defense[32] is "Capabilities built into, strapped onto, or plugged into operational materiel systems to train, sustain, and enhance individual and crew skill proficiencies necessary to operate and maintain the equipment."

While embedding training has long been a goal of Army designers and trainers, there has been limited achievement. While there are embedded tutorials in many ABCS systems, and collective training capabilities embedded in some weapon systems (e.g., the Hawk air defense missile), most collective training simulations are still standalone (e.g., Bradley COFT) or "strap on" (e.g., MILES). Many software companies now include ET in their software applications, such as graphics tools, word processors, and spreadsheets. The software includes automated tutorials that walk the learner step-by-step through the operation of different features of the application, and this capability is increasingly a feature of Army systems.

For the Army, the concept of being able to get training delivered via organic equipment promises to:

- Save time required to install separate training devices on organic equipment.
- Save transit time to get to and from training facilities and areas.
- Provide ready access to training at the unit's convenience, while at home station, while en route to deployment (e.g., rehearsals, familiarization with terrain and culture) or while deployed.

Although the possible benefits from ET are clear, the costs and implementation difficulties are less clear and provide significant challenges to designers and developers. An Army Research Institute (ARI) study identified a number of factors that should guide the decision on when to embed training, including "policy; system availability for training; technical feasibility of ET implementation; effects of ET on system reliability, availability, and maintainability; impact of ET on system manpower and personnel requirements; need for training-specific inter-

[32] "Development, Management, and Delivery of Distributed Learning," Department of Defense Instruction Number 1322,26, 16 June 2006.

face hardware; safety; and cost-effectiveness."[33] There are situations in which the costs of embedding training into a device (e.g., size, weight, development time and effort) outweigh the benefits of ET. Although achieving an ET capacity has long been an Army goal, the attainment in current BCTs is modest, limited to embedded tutorials and operator trainers on selected systems.

Proposed Embedded Training Enhancements, Likely Benefits, and Limiting Factors

The Future Combat Systems' required capabilities include the following "Training Capabilities":

> Enable operators, maintainers, unit leaders, and staff planners to be trained in system functions by leveraging any or a combination of networked, embedded, virtual, constructive, or live training mode anywhere, any time.[34]

The FCS requirements include KPP 6 on training, which states that the "FCS must have an embedded individual and collective training capability that supports live, virtual, and constructive training environments." This is to be achieved through a "Full Task Training" (FTT) capability that is specified to be achieved for "individual, crew, and multi-echelon training without reconfiguration of the equipment."

There is also a requirement for a set of tools and capabilities to support ET. These include onboard repositories of training products[35] to support sustainment of skills at all unit locations. Also included in the specifications are the capability to generate SAF, an AAR tool, and tools for managing use of ET and record-keeping. These tools and capabilities will be provided via TCCs and are specified to be applications reused from ATIA, CTIA, OneSAF, and OneTESS. Included is

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[33] Robert G. Witmer, *A Guide for Early Embedded Training Decisions, Second Edition*, U.S. Army Research Institute for the Behavioral and Social Sciences, 2003.

[34] TRADOC Operational Requirements Document, *Future Combat System*, April 2003.

[35] Technical manuals, MOS information, TTPs, MTPs, TSPs, interactive multimedia instruction courseware, and collective task training information.

the concept to have a progressive training matrix similar to those found in the tank Conduct of Fire Trainer (COFT).[36]

In general, the quality and adaptability benefits of ET are limited to the capability being embedded. For example, the benefits of embedded interactive multimedia instruction (IMI) will be no better than that of the IMI being embedded. Thus, ET can potentially increase the quantity, but not the quality or adaptability, of the capability embedded. The likely benefits to the BCT from ET in the 2016 timeframe are also limited by the availability of ET only for FCS systems.

The goals of ET are global, but the actual training benefit will vary considerably by FCS system and specific embedded training capability. For example, the potential benefit of ET for UAV operator training will be considerably different from virtual multi-echelon trainer (e.g., CCTT) for a company team.

Table 9.2 summarizes estimates of the likely benefits and limiting factors of ET across a range of training capabilities. Our estimates focus on the degree to which embedding the capability will significantly increase the amount of training conducted. We do not consider the quality and adaptability ratings as relevant for ET, as this capability merely supplies a means to provide via operational equipment other capabilities (e.g., virtual or constructive simulations), which are rated separately.

- **Live TESS.** While there will be some unit workload reductions, there will be a limited increase in the quantity of live training from ET in the foreseeable future, given training area constraints and the amount of time units currently spend doing live training. Since a majority of the participants in live training (e.g., dismounted soldiers, OPFOR) will not be FCS-equipped in the 2016 timeframe, embedded TESS will not significantly increase this type of training even when these units are deployed.

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36 The COFT has a series of progressively more difficult engagement events. More basic tank gunnery skills must be successfully demonstrated before the crew moves to more difficult ones.

Table 9.2
Embedded Training Capabilities: Likely Benefits and Limiting Factors

Embedded Capability	Likely Benefits of Enhancement	Limiting Factors
Live TESS	• Reduced time spent to acquire and install • Access while deployed	• Only FCS will have embedded training
Virtual Operator/ Individual Trainers	• Use organic equipment • Access anytime	• Only FCS and related technologies will have embedded training
Virtual Crew/Squad (e.g., COFT, Squad Soldier-CATT)	• Use organic equipment • Access whenever FCS equipment is available	• Only FCS will have embedded training • Will not support embedded Soldier-CATT Squad
Constructive Command and Battle Staff Training	• Access whenever FCS equipment is available	• Space/capability for work-station and simulations center requirements in FCS systems
Virtual Multi-Echelon (e.g., CCTT)	• Access whenever FCS equipment is available	• Not likely embedded until long after 2016 • CCTT limitations
Leader Skills Trainers	• Improved access via vehicle information system	• Amount and training level of content
IMI-Based Training	• Improved access via vehicle information system	• Amount and training level of content

- **Virtual Operator/Individual Trainers.** There appears to be significant potential in this ET capability across most FCS systems to increase the quantity of training. In fact, given that many systems will be used as designated systems, and that frequent sustainment training will be needed for many such systems, this may be the embedded capability with the highest benefit.
- **Virtual Crew/Squad (e.g., COFT, Squad Soldier-CATT).** Embedding a crew-type training capability appears to be feasible on FCS weapon systems. Given the potential to include limited motion in this type of training when using the weapon system, this is a case in which the quality of training could also increase for some systems. Given the high likely costs of training on precision weapons requiring extended range capabilities, crew weapon system trainers could bring some of the highest benefits. However, because

there will be no embedded dismounted virtual capability available by 2016, there will be no embedded Squad Soldier-CATT capability.

- **Constructive Command and Battle Staff Training.** While feasible in the 2016 timeframe, and providing the obvious benefit of allowing easy use of tactical C4 systems, embedding constructive simulations capabilities will not likely increase the implementation of this type of training. The use of tactical vehicles as workstations may be technically and physically difficult. Moreover, embedding this capability will not reduce the key causes of their current low usage, namely, limited realism and high support requirements.
- **Virtual Multi-Echelon (e.g., CCTT).** Limitations in CCTT and Soldier-CATT will limit the benefit here. Technically achieving linkage between vehicles and projecting visuals into operational sights will present great difficulties. Although some capacity is potentially feasible using wireless or hard wiring between vehicles, projecting images into operational sights is unlikely to be affordable in the foreseeable future. Moreover, the issues with providing constructive workstations (e.g., for dismounted infantry) discussed above would limit the amount of added events.
- **Leader Skills Trainers and IMI training.** If the ET requirements do not degrade system functionality or portability and the appropriate resources are dedicated, these ET capabilities could realistically be implemented and benefit training of all FCS personnel. Each system will include an information system (e.g., processors, input and output devices), which will have an interface that could be designed for operational and training purposes. For example, ET could facilitate familiarization with terrain and culture for deploying or deployed troops.

Conclusions on Embedded Training Enhancements

Our general conclusion is that there are some potential benefits from ET to improve the quantity of training on some FCS systems in the 2016 timeframe. The biggest benefits to training from ET should come in the areas of:

- Virtual training for system operators and crews.
- IMI and tutorials.
- Constructive training of battle command skills for BCT commanders and staffs via battle command C4ISR systems.
- Constructive leader training skills.

However, there will be no quality or adaptability improvements beyond those of the training capabilities being embedded. There is no reasonable basis for believing that embedded training will reduce the need for OPTEMPO to support live training.

Training Manpower Support for Home Station Training

In this section we examine the benefits of the manpower resources (both existing and planned enhancements) that installations and other organizations provide to assist commanders in planning, preparing, conducting, and evaluating training and training events.

Current Capabilities and Challenges

Installations have manpower resources to assist commanders in planning, preparing, and conducting training and training events. These include the staffs in CCTT facilities and Battle Simulations Centers as well as the organizations that support the scheduling, maintenance, and operation of ranges and maneuver areas and that maintain and store MILES and other TADSS.

CCTT facilities are far closer to providing a “roll on–roll off” capability than are the Battle Simulations Centers. The CCTT facilities have contract and military civilian capability to maintain and operate simulations, as well as to provide OPFOR and trainers. Battle Simulations Centers, which support constructive and other simulations training, have a very limited number of authorized trainers and OPFOR players.

New Equipment Training Teams (NETT), resourced by the system’s Project Manager, provide training in the form of classes and other instruction to units receiving the new systems.[37] NETT training is primarily oriented toward operators and maintainers, but also provides a limited number of courses for leaders. Proponent schools and CTCs can also sometimes provide mobile training team support for new systems.

Despite these resources, the majority of the effort to plan, prepare, support, and execute training is provided by the tactical units themselves. Tactical unit support is drawn from a wide range of sources, depending on type and echelon of training.

- **Live-fire ranges**. While installations provide some personnel to maintain live-fire ranges and to operate targetry and instrumentation, the unit itself provides the majority of the support personnel on the range.
- **Live collective training events**. Platoon and lower-level training events are generally planned and supported at battalion level, company-level events at brigade level, and battalion- and BCT-level events at the division level. For heavy battalion- and BCT-level field training, the support resources generally came from another organization, e.g., for a battalion-level STX, the OCs, OPFOR, and fire markers typically come from another divisional BCT.
- **Virtual and constructive collective training events**. CCTT platoon and company training was normally planned and supported at company level. Constructive-simulation-supported leader training events were generally planned and conducted by the echelon being trained, but often with some support from the next-higher echelon. For example, the division could provide an Operation Order (OPORD), staff personnel to receive BCT reports, and OPFOR assistance for a BCT-level CPX. To improve the ability of units to conduct simulations training, the Army has established Functional Area 57, which is made up of officers with a specialty in simulations operations. Currently two officers from this specialty are assigned to each division.

[37] NETT training requirements are described in Chapter 5, AR 350-1, *Army Training and Education*, dated 9 April 2003.

Thus, extensive time and manpower are needed to plan, prepare for, and execute training events. In general, training events involve the efforts not only of the training audience (e.g., platoons for a platoon STX), but also usually of the next two echelon organizations, various supporting organizations, and other higher headquarters elements.[38]

In general, this system has proved to be reasonably effective. Commanders and training staff members we interviewed felt that the chain of command should conduct training and that there were training benefits derived from performing OC and OPFOR duties. As we saw in Chapter Five, training programs at home station combined with a CTC rotation were sufficient to train most companies and platoons adequately on most tasks. While the performance of many battalion- and BCT-level tasks and skills showed need for improvement, the recent combat performance of Army units in Iraq and Afghanistan certainly indicates a high level of training achievement for those echelons as well.

Challenges in the current system, especially in light of recent operational requirements and deployments, often derive, in part, from the general reliance on self-support for home station training. These challenges can be summarized as follows:

- We found that a CTC rotation was a necessary adjunct to the home station training, supporting a contention that it was difficult for self-support to provide the level of realism and feedback needed to reach full training readiness needs.
- We also found that the number of training events conducted was far below the level described as necessary in the CATS strategies, with the time needed to plan, prepare, and support the training being a part of the reason.
- We also found a low use of constructive-simulation-supported leader training events and note that the lack of time to prepare for these events was a key factor for the low usage.

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[38] The process to plan and prepare training events is described in detail in several Army documents, including FM 25-4, *How to Conduct Training Exercises*; TC25-10, *A Leader's Guide to Lane Training*; and Coordinating Draft TSP 07-1-S-9-9403, *SBCT Exercise Training Support Package*.

- Unit trainers stated that support from range support personnel and other installation support was limited. For example, unit staffs often had to exert great effort to successfully coordinate realistic live-fire exercises, thus detracting from the time available for internal battle command and staff training programs.
- We found that the current heavy level of deployments has reduced the ability to obtain training support from sister units, at the same time that COE complexity has increased preparation and execution workload. These factors have limited home station training, and have led to a somewhat greater reliance on the CTCs to provide company and battalion STX (formerly done almost exclusively at home station) in addition to a BCT-level FTX.

Proposed Enhancements and Likely Benefits

The primary program enhancements for home station training are the Battle Command Training Center (BCTC) Concept, the exportable training capability (ETC), and the expansion of the BCBST program to cover AC BCTs.[39]

BCTC. The Battle Command Training Center is outlined in the Army Digital Training Strategy. Under this initiative, facilities, equipment, and civilian manpower will be allocated to train new digital operators and maintainers and to provide for their sustainment training. Additionally, there will be classes to teach leaders the fundamentals of using digital equipment, and to support leader training exercises from team through BCT level. Thus, these centers will perform the functions of the predecessor Battle Simulations Centers and also include digital training capabilities. Currently, there are funds to support the BCTC beginning in FY06, and about 700 to 800 personnel

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[39] A final possible home station training support enhancement outlined in the UA O&O plan is the establishment of Home Station Operating Centers (HSOC). While these organizations seem mainly focused on operational support, they may have some potential to support training. However, because we have not been able to find any detail, we do not assess HSOC capabilities in this report.

have been allocated for this capacity in FORSCOM, a considerable increase over the current Battle Simulations Center staffs.[40]

The BCTC has the potential to improve units' ability to conduct simulation-supported training. Its larger training staff could improve the quality of constructive-supported leader training, and, by increasing the benefit and reducing the unit preparation workload, increase the frequency of such events. It could also better design training events to meet the unit commander's needs, thus improving the adaptability of training.

This initiative could also improve the quality of virtual and live as well as constructive training events by providing for a more available wrap-around capability (see the discussion in Chapter Six). Finally, the BCTC also could also provide for sustainment of C4ISR skills.

ETC and BCBST. Another enhancement is the formation of a Brigade Command Battle Staff Training (BCBST) program to provide training for AC BCTs. Under this program, each BCT will receive a week of battle command seminar training for battalion- and BCT-level commanders and staffs during the reset/train period and a week of well-supported BCT-level simulations-supported CPX training. This is far more effective support than could be provided by units themselves with only BCTC support.[41]

To meet increased throughput demands at CTCs, the Army is planning to provide an exportable training capability (ETC) to conduct a CTC-like battalion-level training event at home stations or at training "centers of excellence" sites additional to Fort Irwin and Fort Polk. Key to achieving this capability will be forming two exportable CTC teams. An exportable CTC event is to be far better than could be provided at troop unit home stations with self-support, but with less capability than current rotations at the CTC installations. The exportable CTC capacity will include an Operations Group to plan, prepare, and conduct training support functions, an OPFOR cadre to train units performing OPFOR and role player duties, and a capacity

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40 See *The Army Digital Training Strategy,* September 2004.

41 See briefing, *BCTP Implementation of CTC Way Ahead*, March 2005 CTC Conference, March 2005, Fort Leavenworth, KS.

to provide increased instrumentation at the training site. The exportable Operations Group is currently planned to comprise 487 military and DA civilians.[42]

The ETC and the extension of the BCBST programs can support home station training in the area where increased support is most needed, the conduct of realistic higher-echelon live training events.

Limiting Factors to Proposed Enhancements

There are some concerns with the ETC and extended BCBST programs. While these programs have the potential to effectively support home station training, they essentially add only three events every two years to the BCT training schedule. Further, even this increase in the number of events could be negated by counterbalancing unit decisions. For example, if units stop doing the self-supported home station CTC battalion/BCTC level ramp-up events prior to the CTC events because of overall time constraints, there will be no improvement in *overall* training event frequency. Moreover, the ETC will still face constraints in the areas of training areas, facilities, and OPFOR support, limiting its capability to execute realistic live training at BCT and even battalion levels at many installations.

Our larger concern centers around training needs for the digital C4ISR systems of FCS-equipped BCTs. The basic problem is that the current BCTC and NETT programs were designed for predecessor conditions and requirements. NETT is currently designed to support training solely when units receive a new equipment set. Importantly, C4 systems software upgrades are generally not considered a NETT responsibility. Units are responsible for sustaining individual and collective proficiency after the initial training provided by NETT. The BCTC is designed to assist the unit in this difficult task by providing NETT-like digital qualification training for new operators (when, under the system of individual replacement, they would arrive at units with no NET training), and by providing training for the sustainment

[42] This ETC concept was described by LTG William S. Wallace, Commander, Combined Arms Center, TRADOC in a briefing, *CTC Way Ahead*, during the March 2005 CTC Conference at Fort Leavenworth, KS.

of digital skills for existing operators and for support of digital training embedded in collective and leader training exercises.

The BCTC and NET would have to be reshaped to support initial individual digital training as well as sustainment and Battle Command under ARFORGEN/lifecycle manning programs. Considerable change will be needed, and currently programmed resources may not be adequate.[43] Under lifecycle manning, the force generation strategy generates a new requirement to train a large number of newly assigned operators, maintainers, and leaders early in the reset/train phase, even though unit equipment will not change. This individual training must be completed to allow effective implementation of the collective training. This means that a "NETT-like" requirement will be needed to quickly train a BCT on a surge basis, and this requirement will exist every three years for each BCT (and thus nearly continuously for the Army as a whole). The current NETT program has not been resourced to handle this recurring requirement (given the units will not be receiving new equipment), and installation BCTCs are designed to handle a "steady state" rather than surge initial individual digital qualification requirements.

One danger is that a major portion of the BCTC capability could be consumed in addressing the requirement for periodic NETT-like training, rather than supporting sustainment, leader, and collective training.[44] Once initial systems training is completed, the primary training requirement for the BCTC shifts to collective use of C4ISR systems, with a continuing need to sustain skills in already trained individuals. The increased number of C4ISR systems in FCS-equipped BCTs and the effective use of these systems to generate operational capability generate a greatly increased requirement to train past basic operator training and sustain and adapt those skills to revised METT-TC.

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[43] In our discussions with FORSCOM staff we have learned that the need to modify the program is understood, and modifications are under way. But it is acknowledged that implementing the needed changes will be difficult.

[44] This is because BCTC personnel would have to be continually shifted to the installation needing "surge" support.

Other factors have also potentially changed the needs of the BCTC. On the one hand, lifecycle manning could lead to significant changes in the major objective of the BCTC, which was originally designed to train newly assigned operators who arrive at the units with no NETT training. On the other hand, restationing and modularity have increased the number of brigades to be supported (implying the need for more BCTC assets) and altered their locations.

Moreover, the current operational concepts are heavily based on achieving a high level of collective proficiency in use of C4ISR systems across a wide range of METT-TC, and the research documented in earlier chapters suggests that frequent digital sustainment and battle command training exercises will be needed to achieve these levels. While desired frequencies and type of the training necessary to achieve these levels cannot be defined at this time, they will almost certainly be far larger than the number done currently. Moreover, the integration of C4ISR system operation into all types of training events will increase the need for the BCTC to support live as well as virtual and constructive leader training exercises.

Conclusions

The likely benefits and limiting factors of the enhancements, as well as the continuing challenges in this area, are summarized in Table 9.3. Our overall assessment is as follows:

- **We find that the new enhancements (the BCTC, ETC, and BCBST) will provide for some increases in all three areas: the quality of training, the number of events that can be executed, and the adaptability of the training system.**
- **It is not clear whether the new initiatives will be sufficient given the overall needs in this area, and whether the resulting set of new and old training support organizations will have enough flexibility to provide support across the wide range of events in the emerging training strategies.** Effective implementation and adaptation of the programs to achieve the potential benefit will be necessary and difficult. A major issue is that neither the BCTC nor NETT programs are shaped to support digital

Table 9.3
Training Support Manpower to Unit Training: Likely Benefits and Limiting Factors

Enhanced Capability	Likely Benefits of Enhancement	Limiting Factors
BCTC/CCTT	• Increased BSC support • Digital sustainment • NET training for replacements	• BCTC not designed for current needs—support of digital sustainment and Battle Command under ARFORGEN/lifecycle manning programs
NET/DET	• Trains equipment operator and maintainer skills at initial fielding • Capability not programmed for enhancement	• Designed only for initial fielding, not reset/train • Covers only basic operator/ maintainer training • Ability to handle lifecycle manning "surge"?
ETC/BCBST	• Added quality HS events • ETC • BCBST seminar and CPX	• HS maneuver area constraints • Dependent upon unit and installation support
Self-Support	• Capability not programmed for enhancement	• Sister units less available • Units have less time available • COE complexity increases prep
Other: Training Support Center, Range Control, etc.	• Capability not programmed for enhancement	• Support is limited; frequent complaint of units

sustainment and Battle Command under ARFORGEN/lifecycle manning programs. In addition, while self-support is still the primary source of manpower support for unit training, that capacity could well be decreasing.

- **Redesigning the new enhancements to meet current needs will be a challenge.** If additional resources are required, as suggested by our previous discussion of the unresourced training requirements, these resources may be difficult to come by. Obtaining additional military manpower is extremely difficult in the present programming environment. We heard many positive comments from officers about the value of officers in Functional Area (FA) 57, who specialize in simulations, but the Army has so far allocated only two such officers to each division. Another ongoing issue concerns the difficulty of increasing the TDA (Table of Distribution and Allowances) of the CTCs' military trainers to upgrade their capabilities. While contracting is a possible solution, obtaining personnel with the current experience and knowledge needed will be a challenge.

- **Moreover, providing POM dollars for increasing training support manpower is only the start of the process of developing an effective capacity.** Effective execution will be key to achieving the potential benefits of these enhancements. For example, if unit commanders choose not to use some of the new capabilities (like they currently tend to underuse current simulation capabilities), then little benefit can be realized. In the case of the BCTC, the difficulty of execution is increased due to the change in conditions under which the program was planned.

CHAPTER TEN

Assessment of Other Planned Enhancements

This chapter presents an evaluation of the remaining four capabilities that we identified for supporting the Army training strategy. The capabilities are:

- Lifecycle manning.
- Institutional training initiatives.
- TRADOC collective training support products.
- TRADOC execution of FCS-equipped BCT initial fielding.

Some of these initiatives have already been put in place to some extent, while others are in the planning stages.

Lifecycle Manning

Since World War I, the Army has used an individual replacement system, under which soldiers rotate in and out of units on an individual basis and can change jobs or be transferred to a new installation at any point in time. The goal behind this system has been to give Army managers maximum flexibility to shift personnel as needed in order to have the right person in the right job at the right time. However, reliance on the individual replacement system has meant that units have been responsible for managing the effects of losing and gaining personnel. High rates of personnel turnover have raised concerns about the impact on soldier training time and overall performance and readiness. As a result, the Army has set a goal of stabilizing units.

Proposed Enhancements and Likely Benefits

Lifecycle manning is an ongoing initiative under which units are stabilized for a period of 36 months. During this period, the stabilized unit will be stood up and will go through train-up, a period of sustained readiness, possibly a deployment, and then breakup at the end of the cycle. Stabilizing a unit in this manner can have a positive, though indirect, effect on training. Because fewer personnel will be displaced during the unit's lifecycle, the unit should be able to spend less time on retraining and more time on improving overall capability.

Lifecycle manning has the potential to help units maintain a higher level of readiness, as suggested by the notional illustration in Figure 10.1. The figure provides a view of the way in which lifecycle manning (indicated by the solid line) can help units attain and sustain a higher level of readiness across the first two phases of the ARFORGEN cycle, compared to the traditional individual replacement system (indicated by the dashed line).[1]

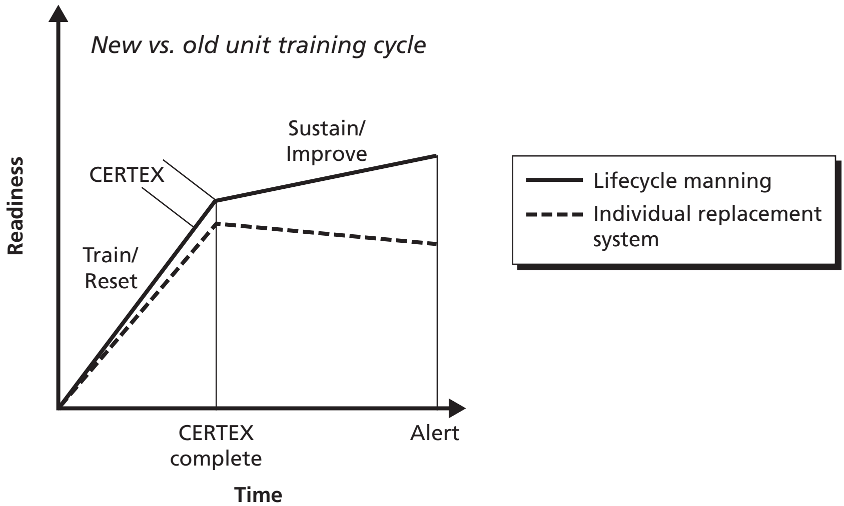
The cycle starts with the unit going through "ramp-up" training during the reset/train period to prepare for a CTC rotation; this program would include platoon through battalion/BCT STXs and gunnery events, and would culminate with the completion of a CTC-level training event (i.e., indicated in the figure as a CERTEX, or certification exercise). Improved readiness during the ramp-up period can be achieved because of the greater degree of personnel stability possible under lifecycle manning. Because there is less chance that personnel will leave or enter the unit during the ramp-up, units can improve more rapidly even without increasing the number of training events.

The benefits of lifecycle manning would likely be greatest during the sustain/improve period.[2] Because the unit will have the same personnel for three years, it can potentially build on the proficiency levels established during the CTC event, incorporating lessons learned and

1 The figure assumes that units are going through the same type of training cycle as that undergone by the heavy units examined for the 2001–2002 timeframe.

2 Our discussion is theoretical because the degree to which personnel stability reduces the requirement for sustainment training is a matter of some conjecture, as there are limited data to support firm conclusions in this area. Most data suggest that stability will make greater levels of training readiness possible; just how much greater is uncertain.

Figure 10.1
Benefits Come During the Reset/Train and Sustain/Improve Parts of the ARFORGEN Cycle



RAND *MG538-10.1*

correcting training shortcomings. Training events conducted during this period would include monthly digital sustainment training, a semi-annual platoon STX (situational training exercise), weapons qualifications/gunnery exercises, and quarterly platoon- to BCT-level CCTT and constructive simulation training. In contrast, under the individual replacement system, movement of personnel in and out of the unit creates intra-team discrepancies in training levels, leading to the need for more sustainment training events and degrading readiness. For example, units have typically experienced significant turnover of personnel and a drop in unit readiness following a CTC rotation.[3] In the end, high levels of personnel turnover require the unit to use much of its available training time to bring new personnel up to speed rather than to build on its readiness.

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[3] We have discussed maintenance of training readiness following a CTC rotation with a wide range of Army commanders and training staff members. The consensus is that a unit can maintain its readiness for two to three months but after that it will typically go into a decline.

Limiting Factors

The extent to which the Army achieves the full training benefit from lifecycle manning will depend largely on whether units achieve a corresponding high degree of positional stability within the unit. Positional stability means that an individual not only stays in the same unit, but also stays in the same job in that unit. Positional stability would allow units to limit the amount of time spent retraining personnel who move into new positions and would allow the unit to focus instead on improving proficiency or reinforcing highly perishable skills, such as digital skills. At present, it appears unlikely that the Army will achieve full positional stability for three years, in part because of potential conflicts with professional development needs. For example, if a brigade's lifecycle is three years and all officers are stabilized in the same position for three years, then only about half of the BCT's captains will be afforded the opportunity to command a company, a key developmental event for captains. Numerous similar examples exist.

Moreover, coordination of unit assignments with Professional Military Education (PME) programs will be a challenge. Periods for schooling are generally dictated by promotion or "time in service" requirements, yet achieving the goal of timely institutional training during the ARFORGEN cycle would mean attending schooling or individual training on a schedule consistent with unit needs—one that allows for completion of institutional training prior to the start of the "train" phase of a soldier's or leader's unit. Alternatively, the Army could provide for leaders to attend resident schooling for short periods during the unit's lifecycle, presumably after the key train-up period at the beginning of the lifecycle.

Conclusions

The likely benefits and limiting factors of lifecycle manning are shown in Table 10.1. To summarize our assessment of lifecycle manning:

- **We think that the potential training benefits of lifecycle manning are significant.** While the enhancement does not directly increase quality, quantity, or adaptability of training, it does have

Table 10.1
Lifecycle Manning: Likely Benefits and Limiting Factors

Enhanced Capability	Likely Benefits of Enhancement	Limiting Factors
Lifecycle manning	• Allows units to build readiness • Facilitates sustainment training • Facilitates ARFORGEN	• Harder to align with PME • Positional stability difficult to achieve

the potential to indirectly allow the BCT to achieve greater training readiness than would likely be achieved by a unit executing the same training events but operating under individual replacement systems.

- **The degree of effectiveness of lifecycle manning for training depends on the degree of positional stability that can be achieved.** While lifecycle manning appears to be desirable from the perspective of unit readiness, individuals' interests in career development and other factors will likely require job changes within the unit during the three-year stabilization cycle.

Institutional Training Initiatives

As described in Chapter One, TRADOC, through its training institutions, provides several kinds of support to units to assist with operational training. Proponent schools provide Initial Military Training (IMT), PME, and functional courses. TRADOC also provides a limited amount of reachback and mobile training team support. In addition, the institutional domain supports unit training and self-development training by providing commanders and leaders with training support materials and products and providing high-quality collective training through the CTC program. Proponent schools also develop the requirements for TADSS, including ranges and targetry.

In recent years, TRADOC has instituted several changes to increase certain types of training, to expand options for delivering training, and to tailor individual training to unit requirements.

Proposed Enhancements and Likely Benefits

The proposed enhancements in the institutional domain tend to be broad initiatives rather than focused on traditionally institutional courses. For example, resident IMT/PME specialty courses are not designated for enhancement.[4] Instead, enhancements are designed to decentralize training and to increase the ability of soldiers and leaders to tap into the Army's accumulated knowledge in something closer to real time.[5] These initiatives aim to create the "schoolhouse without walls," and tend to blur the distinction between institutional and operational training.

Some initiatives are already under way. Examples include the Army's distributed learning (DL) program and initial efforts to implement assignment-oriented training (AOT), an initiative to tailor individual training to the requirements of the gaining unit. A clear trend in many of these initiatives is to reduce formal course lengths, as the Army continues to emphasize efforts to have as many soldiers as possible assigned to TOE units as opposed to attending or supporting resident school instruction.[6] These and other initiatives are discussed further below.

Resident IMT/PME Instruction. To increase the amount of time leaders can spend with units, there have also been initiatives to reduce the number of personnel requiring PME resident instruction. For example, NCO Education System (NCOES) attendance requirements have been reduced. Specifically, the Advanced Noncommissioned Officers Course (ANCOC) is now a requirement for promotion to E8, where it had formerly been a requirement for promotion to E7. The net

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[4] There are some notable exceptions. One example is an initiative to train soldiers and officers during IMT in a greater number of basic warfighting skills.

[5] For a more complete understanding of institutional capabilities and the initiatives outlined in this section, we refer the reader to a separate RAND study, M. Shanley et al., *Transformation and The Army School System,* Santa Monica, CA: RAND Corporation, MG-328-A, 2005.

[6] To cite one recent example, there was serious consideration given to greatly reducing the length of the Captains Career Course (though, after experiments, implementation was cancelled).

result is that a soldier now has a requirement to attend two rather than three NCOES courses prior to attaining the rank of platoon sergeant.

Decentralized Delivery Options. The Army is also providing a greater range of delivery options to make training more widely available beyond the schoolhouse walls. Since the late 1990s, the Army's DL program has offered courses using one or more information and communication technologies to deliver training at decentralized locations. These training modules augment institutional courses and provide Army leaders with increased opportunities for self-development. As an example, the maintenance officer and battle staff courses have been developed into DL courses, and this has the advantage of training many leaders who would not be able to attend resident courses. Overall, the Army plans to convert at least 525 training courses to DL by the year 2010.[7]

The Army goal of creating a networked institutional training system[8] is currently being pursued by the continued development of DL materials, IMI technologies, supporting training architectures, and data repositories.[9] Such technologies will continue to improve due to strong support in the private and educational sectors. Training accessible at almost any location and at any time offers significant potential advantages to leaders and soldiers for increasing both the time available for and the flexibility of institutional training. To the degree that schools can support reachback, these advantages will be even further enhanced for units.

AOT/JIT. The Army is also looking at implementing the concepts of assignment-oriented training (AOT) and just-in-time (JIT) training as educational strategies to reduce the amount of training that has to be conducted and to improve the benefit of IMT and PME. The concept is to identify and focus institutional instruction on the specific skills, knowledge, and tasks needed by a soldier or leader for a specific posi-

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7 U.S. Department of the Army, The Army Distributed Learning Program (TADLP) "Army Distributed Learning, TADLP Overview, Training to Win!" March 5, 2003.

8 See the Army Training Strategy, August 2004.

9 Training architectures and data repositories, necessary to expand the use of DL, are discussed under LVC integration.

tion, thus maximizing the benefit of scarce training time. The ability to focus training on the most essential components could be especially important in a constrained training environment, given the increased range of SKA (skills, knowledge, abilities) needed by the multifunctional soldier and leader, and the potential need for METT-TC-specific learning for deployment to a specific area of operations.

Battle Command Knowledge System (BCKS). The Battle Command Knowledge System, a knowledge management system, is another institutional initiative to increase the availability of training materials to soldiers in near real time. While currently in initial stages of development, the BCKS has been conceptualized as a system of interactive, collaborative networks that will include web-based repositories of meta-data, subject matter experts, and web services that can be accessed globally through standard web browsers. The vision is for soldiers to use BCKS to expeditiously leverage knowledge to solve real-world operational problems, thus improving organizational performance. This will be done by providing soldiers with direct access to a wide range of experts and knowledge residing within specific units, staff organizations, education and training institutions, the Center for Army Lessons Learned (CALL), and professional communities of practice. Potential advantages of the BCKS are improvements in the quality and adaptability of training, and that establishing such a collaborative network could be done at relatively low cost.

Limiting Factors

Currently, the institutional training domain is constrained by resources in its ability to effectively support traditional training, as well as stay current with the COE and technology change. Most significantly, TRADOC schools are experiencing significant shortfalls in the area of training development capacity. For example, proponent schools have difficulty keeping up with the updating of resident courses to account for emerging concepts and technologies (e.g., C4ISR systems and SOSO). They also lag in providing relevant training development products for training conducted outside resident schools (e.g., individual, collective and leader training conducted by operational units, training conducted by Reserve Component schools, and individual training conducted through DL).[10]

Absent a change in priorities in the programming process, realization of the full potential of the DL, JIT/AOT, self-development, reachback, and BCKS concepts will likely be constrained by a shortage of necessary resources. The investment in training development that is needed to fully support these programs in the COE will be significantly higher than that required under traditional training programs,[11] which are already underfunded.[12] In addition, the need for this investment comes at a time when investment in collective training products also needs additional resources (see the section below on collective training products). The required increases in programmed funding for training development seem unlikely given recent budgetary trends. Training and doctrinal development shortfalls have already resulted in relatively long lead times for fielding DL, self-development, AOT/JIT, and necessary training support materials.[13] While the use of collaborative networks (as envisioned by BCKS) holds some promise and is worthy of further investigation as a faster way to distribute materials, the program cannot fully address the larger training development problem. Further, while initiatives such as SCORM[14] promise some

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[10] See Shanley et al. (2005).

[11] For example, replacing face-to-face instruction with technology-supported DL means that training development materials that previously had only to provide general guidance to experienced instructors, now have to fully document all materials, texts, and references. Moreover, materials that could once be safely updated only periodically (again because knowledgeable instructors could fill in the short-term gaps), will demand rapid updating to keep up with changes in equipment technologies and the COE in near real time.

[12] See Shanley et al. (2005), p. 27.

[13] For example, relatively few courses required for promotion have been successfully converted to DL.

[14] SCORM, which stands for the Sharable Content Object Reference Model, is one of the major themes of the Advanced Distributed Learning (ADL) Initiative, sponsored by the Office of the Secretary of Defense (OSD). SCORM establishes technical standards for the development of digital training material with the goal of making the content reusable and shareable beyond its immediate use. If training developers have full access to, and can easily make use of, existing materials when developing new ones, then the cost and time involved in new development can be reduced.

assistance in lowering the cost of training development (by increasing the reuse of training materials), ultimate benefits remain unclear and seem more likely to lead to a reduction in the rate at which the cost of training development increases, rather than an absolute decrease in the cost itself.

A related limitation is the difficulty and high cost of developing and maintaining DL and self-development (SD) products with enough sophistication to train leaders in synchronization, adaptability, and other complex skills. Most current products focus DL on imparting knowledge only, as opposed to applying that knowledge to higher-order problem-solving. While production of more sophisticated DL training materials is technically possible, these materials are even more costly to develop and maintain than "knowledge only" DL.[15] For example, efforts to develop more sophisticated IMI and desktop simulations to support improved resident and nonresident individual learning have been curtailed by the high initial costs of these efforts.

DL and SD initiatives also face operational challenges at unit level. In particular, the high operational pace (OPACE) for soldiers and leaders in units could make it difficult for them to find time to participate in these programs. Stated another way, the additional burden on units to support more individual training would further strain leaders who are already severely constrained by time. Even if DL materials were fully scripted in IMI materials or simulations, significant training expertise would still have to be provided by the unit for useful training to occur.[16]

Implementation of AOT is also likely to face significant implementation challenges. If AOT is conducted by units after leaders and solders were assigned to positions within that unit, it would place a significant additional requirement on units (beyond the requirement generated by DL and SD, as discussed in the paragraph above) to conduct additional individual training, a requirement for which they are not resourced. On the other hand, if AOT were conducted at institu-

[15] See Shanley et al. (2005), p. 57.

[16] Ibid., especially p. 58ff. Note that this document also argues how these operational challenges might be met by developing a more effective local training system.

tions, it could reduce the flexibility afforded to the personnel assignment process today by more complete training by increasing the lead time required on assignments and the scheduling of needed training. Currently, the personnel community can assign soldiers and leaders to positions based on projected Army needs at the time those soldiers and leaders will complete training or education. Since changes in these requirements can be identified and assignments adjusted accordingly while the training is ongoing, this can mean a relatively short lead time. By contrast, if AOT trains only those tasks needed in the next assignment, those assignments may have to be determined with a longer lead time before training begins.

Conclusions

The benefits and limitations of institutional training enhancements are shown in Table 10.2. Our overall assessment leads to the following conclusions:

Planned enhancements within the institutional domain have the potential to make training materials more available and more focused, and to increase the quantity and quality of training events. Because the initiatives seek to capitalize on the type of DL technologies and networks also developing in the private and educational sectors (as exemplified by the collaborative network that is the BCKS), we conclude that the Army's institutional initiatives should lead to some increase in the quantity and quality of training delivered in the 2016 timeframe.

Limitations to the overall potential are likely to occur due to constraints on resources and difficulties of implementation. Overall quality and quantity benefits in this area are likely to be constrained by resources, especially training development resources, and also by operational constraints, which limit the time that soldiers and leaders have to participate in supplemental training. In addition, the same shortages are likely to limit the adaptability of the training system to rapidly respond to the changes demanded by the COE and increasing technologies.

Table 10.2
Institutional Training Initiatives: Likely Benefits and Limiting Factors

Enhanced Capability	Likely Benefits of Enhancement	Limiting Factors
Resident IMT/PME Specialty Courses	• Capability not programmed for enhancement	• Risk of cuts: student time for PME, school staff • COE and technology change make it hard to keep current
DL/SD/IMI	• Adds sustainment and supplements IMT/ PME • Specialty attendance • IMI and related technologies will continue to improve	• School resources for course development and maintenance limited; SCORM benefits unclear • High cost of going beyond "knowledge" learning level • Difficult to coordinate at unit level • OPACE limits time to participate
AOT/JIT	• Shorter, more focused training	• School resources to develop specialized courses limited • Potential difficulty coordinating with personnel system
Reachback	• Direct support to unit	• School resources to develop and implement limited
BCKS	• Distribute Army lessons learned Army-wide through COP	• School resources to develop and implement limited

TRADOC Collective Training Support Products

In this section we examine the benefits of the primary products (current and planned) that TRADOC proponent schools provide to support the planning, preparation, conduct, and evaluation of collective training.

These products include the Combined Arms Training Strategies (CATS), which establish unit, soldier, and leader training requirements and, in the operational domain, include a description of events in a training calendar. The ARTEP mission training plans (MTPs) provide comprehensive training and evaluation outlines for each of the many tasks trained within operational events. Finally, training support packages (TSPs) provide units with an integrated set of training support materials for planning and conducting individual events in the unit's training strategy. These products are further described below.[17]

CATS. AR 350-1 describes CATS as "the Army's overarching strategy for the current and future training of the force. It establishes unit, soldier, and leader training requirements, and describes how the Army will train and sustain the Army to standard in the institution, units, and through self-development." The CATS was developed to describe collective and leader training exercises needed for a wide range of unit types. An example of a unit type would be a mechanized infantry company, including its platoons. Unit CATS describe events and provide execution guidance, outline the mode of training (live, virtual, or constructive), and list annual event frequency and duration. In addition, CATS specifies required ammunition and lists the hours, miles, or gallons of fuel needed for selected equipment. The suggested number and combination of training events are geared to allow units, in accordance with Army standards, to achieve a "trained" level on both their Mission Essential Task List (METL) and their METL supporting tasks.[18]

The CATS program has been facing a number of challenges in recent years. For example, an unpublished RAND study conducted for the Army G-3 in 2003 (see further discussion of this study in Chapter Three) found that CATS had not been developed for a majority of unit types or for institutions. Moreover, those units that did have a CATS did not often use it; in fact, few of the unit training personnel interviewed in the study even knew of the existence of CATS, and virtually none had used CATS as a basis for developing or managing their training programs. The study also found that CATS were typically based on the "best estimate" of a subject matter expert (SME) from a TRADOC proponent school, but had not been validated through sys-

[17] The Army's description of these products are contained in AR350-1, FMs 7.0 and 7.1, TRADOC Regulation 350-70, and TRADOC Pamphlet 350-70-1.

[18] FM 7-0, "Training the Force, Headquarters Department of the Army," October 2002. This manual describes the METL planning process as well as the methods commanders use to assess their units' training levels.

tematic review of training executed by a significant number of units, nor by any examination of the performance of units on tasks.

Further, as discussed in Chapter Three, units executed far fewer live maneuver or simulated training events than were called for in CATS, and take considerably more training time and OPTEMPO miles per event to execute than are provided for in CATS. These limitations are especially problematic when CATS are used to assess unit training levels[19] and to recommend training strategy improvements. TRADOC personnel with whom we discussed CATS development were aware of these limitations but lack the resources to fully correct them.

ARTEP MTPs. MTPs are "descriptive training documents which provide units with a clear description of 'what' and 'how' to train to achieve critical wartime mission proficiency."[20] MTPs document the critical collective tasks required to accomplish unit missions, and specify the methods unit leaders should use for conducting training on these tasks. The conditions and standards required for successful task performance are also defined in training and evaluation outlines (TEOs) within MTPs. TEOs provide checklists of the steps required to complete a task, and include performance measures to judge how well tasks are completed.

MTPs are developed for a type and echelon of tactical unit by the proponent school or schools relevant to the tasks involved. For example, there are MTPs for the mechanized infantry platoon, and for both the mechanized infantry and tank company team and the battalion task force that are developed jointly by the Armor and Infantry Schools. The Army has developed a generally complete set of MTPs.

However, the highly detailed quality of MTPs makes them difficult to use in supporting the design and implementation of collective and leader training exercises. An examination of current MTPs for BCTs' primary maneuver units found that TEOs were too detailed to

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[19] For example, as commanders are told to use CATS as a basis for reporting training readiness levels, the overstatement of possible events can undercut establishing an effective, objective set of criteria for assessing training readiness levels.

[20] TRADOC PAM 350-70-1.

provide useful checklists of performance standards and performance steps. For example, the TEOs for the mechanized infantry platoons are well over 300 pages long, and for the company team and battalion task force they are over 400 pages long.[21] Moreover, many of the task and performance step measures are not directly observable and lack objective standards, thus requiring expert judgment on the part of the observer and making automated data collection difficult.[22] As a result, MTPs have little current use for trainers in observing and assessing unit training and facilitating AARs.[23] Finally, even if MTPs could be altered to increase their usefulness, the proponent schools appear to have difficulty maintaining MTP currency in the current resourcing environment.[24]

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21 From our review of MTP content and our interaction with the Operations Groups trainers as part of the CTC project (see Chapter Three), we developed a set of four-page questionnaires for each type of BCT organization. Based on feedback from OCs, we think that this is about the upper limit of a useful assessment guide. Of course, there are other uses of MTPs that we did not assess because they were not relevant to our study. For example, MTPs could be useful in conducting a leader training class, or a TOC drill walk.

22 For example, in the battalion task force MTP task "Prepare for Operations (Infantry Battalion/Tank and Mechanized Infantry Battalion Task Force) (07-1-5198)," the task standard is "The unit prepares for operations in accordance with (IAW) the tactical standing operating procedures (TSOP), the order, appropriate field manual, and or higher commander's guidance. Unit leaders refine the plan based on continuously updated intelligence. Unit conducts extensive reconnaissance and surveillance (R&S). Unit leaders conduct precombat checks. Unit leaders supervise subordinate troop-leading procedures to ensure planning and preparations are on track and consistent with the unit commander's intent. The unit conducts rehearsals during [the] day and [under conditions of] limited visibility if possible. Unit leaders position forces IAW the plan. Unit leaders reinforce Rules of Engagement (ROE) and Rules of Interaction (ROI)." The first task step with performance measure is "Unit leaders gain and or maintain situational understanding using available communications equipment, maps, intelligence summaries, situation reports (SITREPs), and other available information sources." To assess task performance using these standards requires constant observation of unit processes and assessment of their products and requires expert judgment to determine whether the subjective standards are achieved.

23 For example, when we developed OC questionnaires for the CTCs, we interacted extensively with the Operations Group OCs at both the NTC and JRTC and made an extensive effort to observe and understand their methods for observing and assessing unit training and facilitating AARs. We found almost no direct use of MTPs in their training methods.

24 For example, in a recent RAND effort to update its CTC questionnaires to include more on SOSO and digitization, the researchers found limited specific inclusion of these areas in

TSPs. TSPs leverage information from MTPs to provide a tool to assist units in running collective training events. "A Collective/Warfighter TSP is a complete, task-based, exportable package integrating training products, materials, and information necessary to train one or more critical collective tasks and supporting individual tasks."[25] A particular TSP will cover all tasks involved with a training event (e.g., a CPX aimed at attack training for a combined arms battalion). The TSP materials include a description of the exercise, tactical materials (OPORD, scenarios, etc.), exercise control materials (e.g., Master Events and Scenario Lists (MESLs), guides for exercise personnel), exercise start-up materials (e.g., simulation and ABCS initialization materials, starting METT-TC conditions), evaluation plans (observation and AAR plans), administrative materials (e.g., exercise schedule, personnel requirements), and a listing of required references.

Few TSPs exist for the current period. We reviewed a few, including one developed by the Infantry School for a simulation-supported CPX for a Stryker BCT. The package was well-suited to our purposes in that it contained all the components suggested in the TRADOC PAM 350-70-1 and covered a multi-phased operation. We found that the TSP would provide a Stryker BCT with a good guide on how to implement more structured training. In addition, it clearly defined the roles and responsibilities of all the various players in the training event. At the same time, the TSP appeared to be unnecessarily long (containing much "boilerplate") and potentially rather difficult to use; the overly detailed checklists in the MTPs (discussed above) were carried over to the TSP. Moreover, the TSP might well require a great effort to adapt to most training events, as it was specific to only one of the many METT-TC scenarios that units would have to prepare for.

Proposed Enhancements and Likely Benefits

Enhancements in this area are focused primarily on increasing their potential impact by increasing their availability. There are many ongo-

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current MTPs. Instead, the researchers had to rely on more current sources, such as CALL and professional journals.

[25] TRADOC PAM 350-70-1 is the source for this description of TSPs.

ing initiatives to increase the number of the collective training products and to make them more easily accessible and adaptable. For example, changes are being initiated to automate and digitize these products to increase availability and to facilitate their update and modification. There are efforts to improve the user-friendliness of CATS. In both the FCS training and ABCS programs, there are initiatives to develop a set of TSPs that more completely support unit and institutional training. There is also a movement to develop systems to archive and share TSPs across units and installations, which could then more easily modify them to meet their specific training needs. Also under the Army's LVC-IA and FCS Training Common Components programs, there are initiatives to improve scenario generation and AAR development, both requirements of a TSP.

Limiting Factors

The main limiting factor on these institutional training products is the ability of the Army to develop and maintain the underlying content for this extensive set of support products. For example, thousands of TSPs would need to be developed (and continually maintained) to cover the full set of events and METT-TC conditions needed for a comprehensive BCT and subordinate unit training program. In the current budget environment, it seems unlikely that TRADOC resource levels will be increased to allow development and maintenance of the extensive set of TSPs required.

Another limiting factor involves the flaws in these products (as described above), at least when applied to the development and execution of unit training programs. Their present form makes it difficult for units to use them to enhance the training strategy as intended. While ongoing initiatives are likely to make these products more accessible to units, our conclusion is that their basic design would need significant modification before they could be made useful to units in executing their training strategy. In interviews within current units (see Chapter Three), leaders do not cite TSPs as something they need to improve their training outcomes, so it is unclear whether units would find future TSPs beneficial enough to use.

Conclusions

The likely benefits and limiting factors to this enhancement are summarized in Table 10.3. Our summary assessment of the institutional training products is as follows:

- **The collective training products reviewed above provide some training benefit in terms of quality and adaptability.** The products, by their nature, are designed to increase training quality by helping units take a more structured approach to training. Moreover, the plan to make the enhancements more accessible to units should provide some increased training system adaptability. Ongoing initiatives should increase these benefits by providing trainers with better access and an increased ability to update the products to address COE, FCS modernization, and reorganization into FCS-equipped BCT configuration.
- **However, implementing these enhancements on an ongoing basis will be resource constrained, and will involve a high workload effort and low benefit in the current form.** We believe the full potential benefits in quality and adaptability will largely not be realized because effective implementation appears unaffordable, especially if implementation includes some redesign of the products to make them more useful to units.
- **In addition, these enhancements are likely to have little impact on the quantity of training events.** The potential of TRADOC collective training products to increase the quantity of training lies in their potential to reduce planning time. For example, they can clarify which events need to be trained, which tasks are involved, and who is responsible for their execution. However, even if the concerns voiced above could be successfully addressed, we think that the workload on units to prepare, support, execute, and evaluate collective training would far outweigh the benefit in terms of reduced planning time. Thus, we see only a marginal potential reduction in unit workload and time freed for more training.

Table 10.3
TRADOC Collective Training Support Products: Likely Benefits and Limiting Factors

Enhanced Capability	Likely Benefits of Enhancement	Limiting Factors
MTP	• Electronic MTP	• Complex to use for event assessment • Limited resources for update
TSP	• Assist event planning, preparation, and execution • Augment MTPs • FCS program will develop	• Not used or cited as needed; units develop their own • Limited resources (outside FCS) result in limited production • Great effort to adapt to unit use • Thousands needed • Constant updates require high training development (TD) capacity
CATS	• Assist commanders to develop training plans • Potentially provide training "metrics"	• Limited use • Limited resources result in limited production • Disconnect with the training that units conduct

TRADOC Execution of Initial Fielding for FCS-Equipped BCTs

In this section we examine the benefits of TRADOC plans to support the initial fielding of FCS-equipped BCTs.

Proposed Enhancements and Likely Benefits

TRADOC's Institutional Training Strategy is the currently approved concept for standing up and training FCS-equipped BCTs.[26] Under this concept, called Unit Set Fielding, an FCS-equipped BCT is to be formed by sending a BCT to a TRADOC installation where it comes under TRADOC command and control. The organizations at the TRADOC installation would then provide for all the reorganiza-

[26] Our assessment is based on review of a briefing, "Unit of Action Institutional Training Strategy Task Force," dated November 2003, and discussions with members of the team that developed this strategy.

tion, fielding, and training functions, while the unit would receive new personnel and complete reorganization into an FCS-equipped BCT configuration, receive FCS equipment, and complete all initial training (from individual to brigade level) before being returned to FORSCOM. Under this concept, it is estimated that two FCS-equipped BCTs could be stood up each year.

Such a concept would efficiently use resources to stand up FCS-equipped BCTs. The TRADOC team supporting this effort could be formed from those personnel involved in FCS system development, concept development, and initial operational testing, thus incorporating the lessons directly from these efforts. It could facilitate the creation of an assembly-line-like operation, complete with the facilities and personnel to make this a "turn-key" operation that would minimize the workload for FORSCOM and its TOE units. Such a concept provides clear potential efficiencies over having units try to accomplish this process at home station.

This concept could also promote spiral development of FCS-equipped BCT concepts, equipment, systems, and training methods, since the organizations responsible for these areas could be located at the site. Materiel developers could also continue the operational testing of the systems and quickly implement "fixes." Because the proponent schools will support this training, they would have direct knowledge of system capabilities and limitations, and thus would be able to revise doctrine and training materials directly.

Likely Limiting Factors

One limitation of this concept is that it covers only FCS-equipped BCTs at initial fielding. A similar effort would be needed at the end of each three-year unit stabilization cycle, especially if the brigade gets upgraded or adds FCSs. Moreover, this concept, as currently programmed, is not being established to cover "spiral-out" efforts to BCT (see the discussion in Chapter Two). An additional concern is that we have not been able to identify any organization doing the planning and programming to transform the concept into a reality. Establishment of such a site would likely require manpower, including OPFOR, and improved facilities to be programmed into Army budgets. Finally, the enhancement could be altered due to its potential effect on unit OPACE. Achieving the efficiencies of centralized activities would require moving most soldiers from home stations for six months, at a time when they might easily face deployments upon completion.

Conclusions

Table 10.4 shows our overall assessment of this enhancement. The key findings in our assessment are as follows:

- **This concept promises some potential benefits, positively affecting our metrics, the quantity, quality, and adaptability of training.** The enhancement has been geared to maximize the effectiveness and efficiency of training.
- **Its primary limitation is the high risk that the enhancement will not be implemented.** It faces significant funding risk and carries challenges in the area of personnel OPACE.

Table 10.4
TRADOC Execution of FCS-Equipped BCT Initial Fielding: Likely Benefits and Limiting Factors

Enhanced Capability	Likely Benefits of Enhancement	Limiting Factors
TRADOC execution of Unit Set Fielding at TRADOC post	• Allows "production line" for greater efficiency • Promotes school currency	• Resources to support (especially OPFOR/role players) at risk • Increases unit OPACE • Not available for "spiral-outs" or FCS-equipped BCT reset

CHAPTER ELEVEN

Integrated Assessment of Enhancements

In the preceding several chapters, we have examined individually each training enhancement for BCTs equipped with FCS technology. In this chapter, we assess the aggregate value of the enhancements, as well as the balance across enhancements.

We first bring together the individual assessments of the enhancements to present a summary view of benefits in terms of their contribution to improving the quality, quantity, and adaptability of training. To complement the broader look, we also provide a more focused comparative assessment of enhancements in the context of two substantive areas: training of battle command skills, and training requirements of Army modernization. Next, we examine aspects of the Army's budget process with regard to training enhancements and the process's ability to facilitate tradeoff decisions in a resource-constrained environment.

Comparison of Enhancement Benefits

Metrics and Rating System

To compare likely benefits across enhancements, we used three qualitative measures of training program improvement. These were defined in detail in Chapter Four and can be briefly summarized as follows:

- **Training quality**. The potential of the enhancement to increase the desired training effect, as determined by increased training event realism, complexity, and feedback.

- **Quantity of training events.** The potential of the enhancement to increase the number and duration of training events, or the number of soldiers or leaders trained.
- **Adaptability of training events.** The potential of the enhancement to allow events to be adapted to train a wide range of full-spectrum METT-TCs.

To describe the level of improvement to training provided by each of the enhancements, we used qualitative categories of "much," "some," and "minimal." An implied fourth possibility would be "none" for "no noteworthy improvement expected."

An understanding of the focus of these ratings is key to their meaning. First, our assessments were intentionally conservative and intended to measure not what the enhancements might eventually achieve, but what could likely be achieved in the 2016 timeframe. Second, while we felt that all the enhancements had some value, we rated them against a tough standard: the extent to which they are likely to help the Army achieve training levels relative to new training requirements that are comparable to the levels achieved in the predeployment era relative to the requirement to prepare for a conventional high-intensity threat. Third, our ratings were focused on the training benefits for BCTs equipped with FCS technologies. Potential training benefits of the enhancements above brigade level or for other parts of the force (e.g., CS and CSS units) were not considered. Finally, we rated the enhancements only against the metrics described above, and did not consider other possible benefits (e.g., helping to maintain current capabilities or to train more efficiently).

Applying the Metrics

Table 11.1 summarizes the levels of improvement expected from each enhancement in relation to each metric. The enhancements are listed in the order in which they were covered in previous chapters. The second column from the left lists specific enhancements assessed in each category, while the right three columns show the respective ratings for each. While full interpretation of these ratings requires reference to the more detailed information provided in the preceding chapters, this combined assessment illustrates the comparative potential of the enhancements to affect quality, quantity, and adaptability of the training system for modernized BCTs.

Table 11.1
Summary of Effect of Enhancements on Metrics for the Training of BCTs Equipped with FCS Technologies

		Likely Improvement in Training Capability Relative to Requirements in 2010–2016 Timeframe		
Enhancement	**Subsection**	**Quality**	**Quantity**	**Adaptability**
Live Technologies	TESS	Some	—	Minimal
	Targetry	Some	—	—
	Ranges/Facilities	Some	Minimal	Some
	Instrumentation	Some	—	Minimal
CTC-Specific Modernization	Instrumentation	Some	—	Minimal
	Maneuver area	Some	—	Minimal
Constructive Simulations	Battle Command skills	Minimal	Minimal	Minimal
Virtual Simulations	Ind/Operator/maint skills	Some	Much	Minimal
	Crew/Squad skills	Some	Some	Minimal
	Collective skills	Minimal	Minimal	Minimal
Leader Tactical Trainers	Leader skills	Minimal	Some	Minimal
LVC Integration and Tools	LVC Integration	Some	Minimal	Minimal
	Tools to support training	Minimal	Minimal	Minimal
Embedded Training [a]	Live	NA	Minimal	NA
	Virtual Ind/Operator	NA	Much	NA
	Virtual Crew/Sqd	NA	Some	NA
	Virtual collective skills	NA	—	NA
	Tactical Leader skills	NA	Some	NA
	Constructive Battle Command	NA	Minimal	NA
	IMI-based training	NA	Much	NA
Direct Training Support (HS)	BCTC/CCTT	Some	Some	Some
	ETC/BCBST	Some	Some	Some
Lifecycle Manning		Some	Much	Some

Table 11.1—continued

Enhancement	Subsection	Likely Improvement in Training Capability Relative to Requirements in 2010–2016 Timeframe		
		Quality	Quantity	Adaptability
Institutional Training Initiatives	Nonresident DL/SD/IMI	Minimal	Some	Minimal
	AOT/JIT	—	Some	—
	Reachback	Minimal	Some	Minimal
	Battle Comand Knowledge System	Some	Minimal	Some
Collective Training Support Products	MTPs	Minimal	Minimal	Minimal
	CATS	Minimal	—	—
	TSPs	Minimal	Minimal	—
TRADOC Execution of FCS BCT Initial Fielding		Minimal	Minimal	Minimal

NOTE: Ratings reflect usefulness of capabilities for the tactical training of modernized BCTs only (i.e., brigade-and-below training). They do not reflect an assessment of the value of these enablers for other training goals (e.g., for training above brigade level or for CS and CSS units).

[a] In this table, quality and adaptability ratings for "embedded training" are not considered relevant (i.e., receives an "NA" rating) because ET is considered only as a means to channel other capabilities (e.g., virtual or constructive simulations) to increase the quantity of training events. The quality and adaptability of those other capabilities vary by capability, and are rated separately.

To aid in interpretation of Table 11.1, summary assessments of each major enhancement category appear below.

Enhanced Live Training Technologies. All the live enhancements offer some potential to improve the quality of training. We conclude that improving the live capabilities is critical because live training will remain the cornerstone of maneuver unit training. Especially important are initiatives to increase the realism of close-in live-fire engagements and MOUT facilities. The only potential improvement for training quantity comes from the increased number of live-fire ranges and MOUT facilities, but given the costs of these facilities and training area size limitations, this benefit will be achieved slowly.

Maneuver CTC-Specific Enhancements. The CTCs have been critical components of maneuver training programs, and we think this will continue. Enhancements do not affect the "quantity" metric there, as they do not affect throughput. However, we do see some improvement in the "quality" metric. The instrumentation and maneuver area enhancements can help the CTCs effectively train modular, modernized BCTs in the COE environment. This is especially important considering the increased difficulty of conducting such training at home stations. The ability of the CTCs to maintain event quality and a capability to adapt events will depend on maintaining an adequate level of training manpower support for the CTCs. In the past, the CTCs have proven capable of effective adaptation due to the capabilities of their trainers and OPFOR. Additionally, the enhancement of the CTC MOUT training capabilities will benefit adaptation.

Constructive Battle Command Simulations. The OneSAF and WARSIM technologies by themselves will provide limited improvement in training quality and adaptability. While the technologies will provide quality improvements in some areas (e.g., the physics of realistic MOUT combat), limitations in SAF in the 2016 timeframe will make it difficult to simulate close combat and COE conditions. Achieving realism and providing training feedback will still be largely a function of expert trainers, and exercise execution will still require an adequate number of OCs and role players. For this same reason, simulation technologies will also not likely increase the quantity of this type of training.

Virtual Simulations. Technology for individual, operator, and maintainer trainers will likely improve considerably and thus has great potential to enhance this type of training (assuming that adequate funding is provided).[1] The same will likely be true of crew trainers, but the potential of squad trainers will likely be far less.[2] With regard to

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1 The potential will be more limited for individual skills where replication of movement or similar physical activity is needed for positive training transfer.

2 EST has reportedly proven to be a valuable training tool for squads in the past, but proposed enhancements, to include greater movement and other needed physical realism aspects, have not yet been sufficiently demonstrated to estimate benefits or costs.

multi-echelon collective training, we see few improvements in capabilities relative to our metrics in the 2016 timeframe, given what we judge to be their limitations in simulating dismounted and close combat.[3]

Simulation-Based Trainers of Leader Tactical Skills. We see great but unproven potential for "serious games" types of leader trainers to improve the quantity of this type of training, especially for small-unit direct fire skills. These trainers for leader skills will grow in both complexity and breadth of application, but the potential for improving training quality and adaptability will be limited by the same factors discussed for constructive simulations. Like the trainers for other types of individual skills mentioned earlier, the value of these leader skills trainers has to be closely monitored and assessed.

LVC Training Integration and Tools. The Army's efforts to allow its training simulations to be linked together will provide some important training quality improvements in the timeframe of this analysis. For example, the ability for constructive simulations to stimulate operational hardware[4] (a part of the integration effort) is important for maintaining the relevance of constructive-supported training. And a better ability to link training audiences could increase the benefit of leader training exercises, for example, by facilitating "wrap-around" live training (i.e., live training that includes constructive replication of a larger tactical situation than is actually present in the maneuver area).

There will likely be fewer gains in the areas of quantity and adaptability in the 2016 timeframe. Wrap-around will likely provide only small additions to the number of soldiers being trained and to the ability of the simulations to provide training on a wider set of METT-TC events.

With regard to "integrated tools," we see only small improvements to support the design, development, execution, and conduct of

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[3] Indeed, the usage and benefit of this type of trainer could potentially decrease, given these limitations and the costs of upgrading the tank/infantry fighting vehicle simulators (to include upgraded ABCS systems) or to replace them with FCS simulators.

[4] "Stimulation" increases training value because the results of constructive simulations can be transmitted to, and followed on, organic equipment, such as the ABCS and other C4ISR systems.

AARs of training events that have some aspects of LVC simulations integrated. There are still many unanswered technical and training development issues surrounding interoperability in this area, and the basic learning and training design of such complex tools.

Embedded Training. In determining our ratings for embedded training, we considered only the benefit and potential of *embedding* the capability itself; however, the quality and adaptability benefits of embedding a training capability can be no greater than the benefit of that capability itself, which we did not consider in this part of the analysis. Therefore, we provide a rating only for training quantity. Embedding live enhancements will help in a small way to increase the number of live training events because they will reduce the need to strap on TESS hardware.

Embedding individual and crew training virtual capabilities will lead to much greater increases in the amount of these types of training. While few FCS vehicles will be available by 2016, embedded capabilities can occur in other equipment that will be available (e.g., UAVs). Finally, we see little technical likelihood of embedding a CCTT capability in the 2016 timeframe; in any case, the limitations of constructive simulations technology will limit the likely usefulness of embedding this capability.

Direct Support to Home Station Training. The enhancements proposed under these initiatives will provide "some" improvements across the areas of quality, quantity, and adaptability. Increased training manpower can potentially help units address the constraint of leader time to plan, prepare, and execute training events.

Lifecycle Manning. To the degree that positional stability is achieved, this enhancement could significantly reduce the amount of time needed to retrain unit-specific individual and collective skills and thus could lead to indirect but nonetheless important improvement in all three metric areas, especially quantity.

Institutional Training Initiatives. While all these initiatives offer likely quantity improvements, training development resource constraints will probably limit the benefit of these initiatives because it will be difficult to develop and adapt new content. The exception could be the Battle Command Knowledge System, which, given its collaboration concept, could result in better sharing of "lessons learned" across the Army.

TRADOC Collective Training Products. Training development resource constraints and limited use of MTPs, CATS, and TSPs are likely to limit the benefit of these products.

TRADOC Execution of FCS BCT Fielding. This enhancement could provide benefits across all areas and support spiral development of training methods and products. However, the resources to support this initiative are not yet programmed, have challenges in the area of personnel OPACE, and the initiative itself is not planned to address training needs beyond the initial fielding period.

Comparing the data across enhancement categories (i.e., moving through the rows of Table 11.1) suggests that live training will remain the cornerstone of BCT training programs. In particular, the table shows that the likely benefits of enhancements for collective training using constructive and virtual technologies are relatively small over the time period covered by this study. As a result, CTC modernization, live training technologies, and development of an ETC will remain critical for the immediate future.

Comparing the data across metrics (i.e., moving across the columns of Table 11.1) suggests that while many of the enhancements help improve the quality of training at least to some degree, fewer have an impact on the quantity or adaptability of training events. This finding is significant in that, absent an increase in the number of training events and in training event adaptability, the effect of enhancements that increase training quality will be less than the full potential of those enhancements.

Table 11.1 as a whole suggests that while the planned enhancements will provide the potential for improvements to the training strategy, the capability achieved will still be significantly less than that demanded by the future training requirements compared to the level of capability achieved (in relation to the requirement) in the predeployment era. Of the 79 ratings in the table, only four received a "much" rating, and more than half received a "minimal" or no rating.

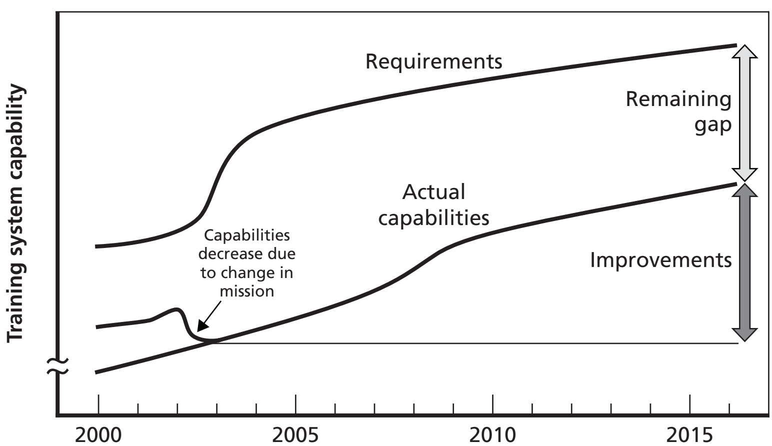
Overall, we found that three enduring constraints in the training system limit what the enhancements can potentially achieve in the 2016 timeframe. The constraints are shortages in unit time to plan, prepare, and execute training; limitations in what technologies can achieve in the near term; and funding risks and resource constraints. Below we review how these constraints affected outcomes in each metric area.

- **Quality.** The table shows "some" likely improvements in training quality for the majority of the enhancements, especially those in the key areas of live and virtual training. Higher ratings would have been possible except that, within the 2016 timeframe, it is unlikely that all planned technology improvements will be able to deliver the larger benefits. Further, benefits may be limited by the high costs of fielding the technologies.
- **Quantity.** Ratings for enhancements based on their potential for increasing the quantity of operational events received the several "much" ratings in the table, one for virtual simulations to support individual, operator, maintainer, and crew skills training; two for embedded training for these same skills; and another for lifecycle manning. However, ratings were low in the key areas affecting live, virtual, and constructive collective training. The most important explanations for these results are limitations in unit time for conducting more live training, and technological and funding risks involved with virtual and constructive simulations for collective training.
- **Adaptability.** The lowest ratings occur in the area of training system adaptability; only 5 of the 24 ratings achieved a level as high as "some." In addition to being affected by the three major constraints indicated above, many enhancements do not appear to have a major potential to increase adaptability to COE changes. As a result, adaptation of training events will continue as a task for commanders on the ground, who will need to set up training that meets their units' mission needs. Clearly adapting training to COE METT-TC is one of the most fundamental challenges facing future Army training.

To summarize our findings at the highest level, we see a gap between requirements and training system capability in the 2016 timeframe. This gap reflects both how difficult new training requirements are, and how high the prior standard was. These conclusions are graphically portrayed in Figure 11.1, which illustrates our expectation regarding changes in training system capability over time.

The figure illustrates notionally the anticipated increase in training system requirements over time (the top line), as well as our assessment of what currently planned enhancements will be able to achieve (the lower line). A "gap" between achievements and requirements already existed in 2000, when the Army was considered to be facing a threat largely related to major theater war. In 2002, requirements began to increase as the true implications of the COE emerged, while achievements (the lower line) initially went down because of the increased importance of stability operations and support operations (SOSO), a mission the training system was not geared to address on the increased scale required. Over time, the Army has been closing the gap, due both to adaptations made by unit leaders and trainers and to training system improvements. The analysis suggests that these improvements

Figure 11.1
Notional Illustration of Changes in the Army Training System Capability Over Time



NOTE: Notional graph.
RAND *MG538-11.1*

should continue out to the 2016 timeline. However, a training gap likely remains because an adaptive enemy implies continued growth in requirements.

Enhancement Benefits in the Context of Specific Focus Areas

To expand the integrated assessment of enhancement benefits, we undertook a more focused look at which enhancements would be especially beneficial in: (a) training battle command skills and (b) meeting the training requirements of Army modernization, especially the spiral-outs. The importance of addressing these areas is further discussed below in the context of the assessment in each instance.

Enhancements in the Context of Training Battle Command Skills

Battle command skills (e.g., information fusion, precision targeting) are key to effective implementation of current and future operational concepts. For example, FM 3-0, *Operations,* which establishes the Army's keystone doctrine for full-spectrum operations, allocates a chapter to this aspect of Army capabilities.[5] Moreover, battle command is a complex function and difficult to master, all the more so considering the complexities of the COE and the range and technological sophistication of C4ISR, lethal, and nonlethal systems available to the FCS BCT. Mastery of battle command skills, especially in light of the COE, will require continual realistic practice in a complex operating environment and under a wide range of conditions. Evidence from previous research on how well battle command skills are executed at the CTCs suggests that many units do not fully master many battle command associated skills (see Chapter Three).

We considered how the balance of training enhancements might best support the development of battle command skills. While live training may provide the best practice, the potential to increase the

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[5] There is also an FM devoted to battle command skills, FM 6-0, *Mission Oriented Command and Control*.

number of battalion and live collective events will remain limited, due to the high cost of such events and constraints on unit time. Thus, BCT training concepts, outlined in the FCS O&O Plan and the FCS STRAP, envision that an embedded constructive simulations capability will make a considerable contribution to increasing the quality, quantity, and adaptability of constructive simulations-based training events for commanders and battle staffs.

However, our research suggests that constructive simulations technologies by themselves will not likely be capable of supporting the need for battle command training in the 2016 timeframe. As described in Chapter Three, units report that the current constructive simulations are rarely used. One major reason is the large workload and high level of expertise needed to plan, prepare, and execute a constructive simulations event; another more important reason is that many users do not believe constructive simulations provide sufficient levels of realism and complexity, especially considering the COE. Our assessment of planned enhancements (see Chapter Six) suggests that it will be difficult to achieve major improvements in battle command training capabilities through constructive simulations technology enhancements by 2016. One major reason is expected limitations in SAF for dealing with close combat and other COE conditions in that timeframe. Another issue concerns prospects for major improvements of AI capabilities in the near future.

Thus, we examined how other enhancements might help improve prospects for constructive-supported battle command training in the 2016 timeframe. This analysis concluded that the key to increasing the frequency and benefits of this type of training is to combine improved constructive technologies with increased training support manpower to assist units in planning, preparing, and executing the events. The Battle Command Training Center (BCTC) and expanded BCBST initiatives provide a basis for growth and improvement of this type. This combination, or rebalancing, of enhancements was judged to offer significant potential for improvement in the quality, quantity, and adaptability of this type of training. A full discussion of this analysis appears in Appendix D.

While the need for sufficient training support manpower was key, the analysis also identified other means of improving battle command training:

- Formalize effective training methods for constructive-supported battle staff training.
- Develop an effective program to train the trainers of simulation-based events to plan, prepare, and conduct battle command exercises driven by constructive simulations.
- Develop effective training support tools for constructive simulations.

To implement such changes, we recommend a spiral development process to effectively evolve the battle command training methods, support structures, and technologies. There is much to learn about conducting and supporting effective leader training exercises, given the constantly changing COE. Nonetheless, a structured method to assess such exercises, measure the training benefits, and develop and implement improvements to organizations, simulations software, and methods, could result in substantial improvement.

Enhancements in the Context of the Training Requirements of Army Modernization, Especially the Spiral-Outs

We also evaluated the role of the enhancements in the context of Army modernization, in particular, the "spiral-outs" of FCS technologies in 2010, 2012, 2014, and 2016.[6] Our goal was to identify those training capabilities that would be especially important for addressing the training needs posed by the spiral-outs and other modernization more generally.

Our research suggested that five training capabilities would be key. The first is TESS support; that is, the unit must be able to use the systems tactically during live training. For example, if Intelligent Munitions Systems are to be employed by maneuver and engineer platoons

[6] The specifics of these technologies, and the training demands they create, are discussed in Chapter Two.

and companies, the systems must be able to replicate tactical lethal and nonlethal effects so that leaders and soldiers can learn needed tactics, techniques, and procedures (TTP). While it would be desirable to have capabilities up to BCT level for home station live training, effective home station company and platoon lane capability is necessary at a minimum, with up to a BCT capability at the CTCs.

A second capability is the need for training simulations to incorporate the new systems and to allow leaders to realistically exercise their tactical employment. Replication of the new systems' actual capabilities, necessary for effective "realism," should be determined through testing, as opposed to merely incorporating those listed in requirement documents. If simulations produce effects that are different from those the system can produce during actual operations, soldiers and leaders can easily learn the wrong lessons.

A third key capability is adequate New Equipment Training (NET) team instruction, including effective courses and "leave-behind" training materials to support sustainment training. This training and equipping must be conducted early in the training cycle to allow units to train collectively with trained operators and actual operational capabilities. Effective NET should be provided not only for initial fielding, but also during the "reset" portion of the ARFORGEN training cycle. Likewise, the specific capabilities and limitations of the new systems, and at least a general tactical concept for the operational employment of the systems, need to have been documented and provided to unit leaders through Doctrinal Training Teams.

Fourth, the systems should be fielded with validated sustainment training capability, which includes training support materials, simulators, etc. In this regard, operator and crew training should be a priority for embedded training capabilities.

Finally, it is important to improve training capability in the area of C4ISR training methods and means. C4ISR systems have a large but as-yet untapped potential to encompass a wide range of operations and conditions that make up the possible current and future operating environments. Moreover, C4ISR systems are undergoing continual change as part of the spiral-outs. Improved battle command skills are at the heart of mastering new operational concepts.

While many of the capabilities specified above might seem obvious, planning and programming actions, if not already initiated, must begin almost immediately to ensure that these capabilities are in place for Spiral 1. And given the large potential impact on training for Spiral 3 (more training time needed to train on new unit systems), near-term improvements in the training system will be necessary to prepare for the additional training needs.

Assuring that the planned training enhancements are provided in time to support the accelerated fielding of the operational capabilities of the spiral-outs is important to leveraging the investments in operational technologies, and likely requires emphasis. For example, it is reasonable to state that the degree to which C4ISR potential will be achieved will be strongly related to the degree to which battle command skills training can be realized. While TESS support of the spiral-outs is clearly planned, it is not clear whether that support will be constrained in the 2010 timeframe due to fielding schedules or a lack of funding. Nor is it clear to what extent OneSAF will be able to incorporate the spiral-outs by 2016. And while PMs ought to provide NET support for the new technologies, as well as virtual training for operator and crew training, it is not clear whether the support will be sufficient to meet all training needs.

Investments in Training Enhancements

Achieving an integrated and defendable program to support BCT training strategies requires an assessment of not only the benefits of enhancements, but also their costs and funding status. Sound investment decisions and program adjustments hinge largely on achieving a favorable cost-benefit ratio, which requires information on the current funding status of the enhancements.

To obtain information on which of the planned enhancements were funded, as well as on their expected costs, we turned to Army POM data for the period covering FY06 through FY11. While this did not cover the entire period of interest (i.e., to FY16), it gave us a clear idea of the direction of investment in training support enhancements.

For many of the subcomponents of the 12 enhancements, we were able to identify programs that were funded, the amount of the funding, and the percent of "critical requirements" (as determined by DA G-3) that were funded. These data were used to determine the level of "funding risk" associated with each enhancement (as discussed in Chapters Five through Ten). For example, we found gaps in enhancement funding (relative to critical requirements) in the areas of CTC modernization, live-fire targetry, and soldier CATT.

We were also able to total "nonsystem" funding for LVC training technology enhancements. Nonsystem enhancements are those not associated with a specific operational system (like the FCS-UA) and funded by general training funds. Examples of nonsystem enhancements include TESS funding for live training, OneSAF funding for training supported by constructive simulations, and CCTT funding for training supported by virtual simulations. Totaling all forecasted expenditures for research, development, and acquisition (RDA) in the LVC enhancement categories, we found that in FY11, the Army planned to invest nearly $180 million in live enhancements, about $60 million for constructive enhancements, and about $55 million for virtual enhancements. Looking at the balance of investments, these amounts implied a priority for live training enhancements. However, about 40 percent of total RDA funding was reserved for investments in virtual and constructive technologies.

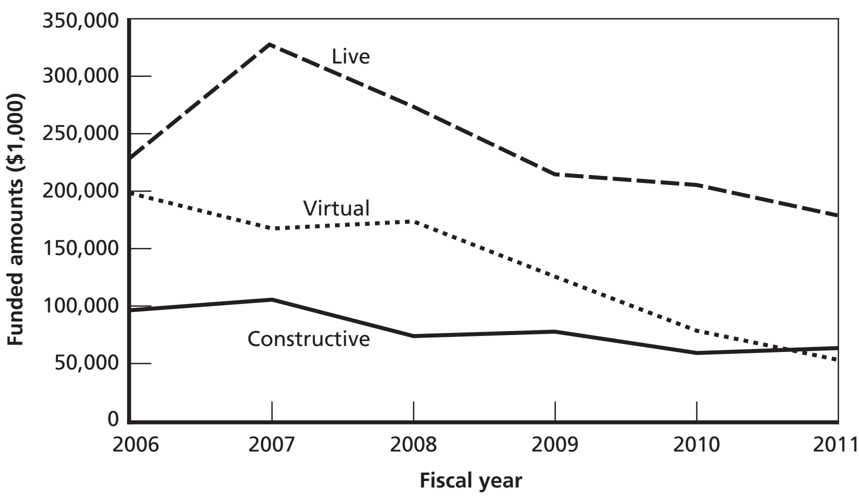
On the whole, however, we were unable to obtain or calculate values for comparable funding amounts across our aggregated enhancement categories. Some of the information was not visible in budgeting data; for example, expenditures for embedded training were funded by program managers who typically do not itemize training expenditures. More often, funding data (e.g., for institutional training strategies) were spread across and embedded in too wide a range of budget categories to make aggregation practical. In addition, supporting resources were sometimes not included within the enhancement category. For example, while we were able to identify funding for specific constructive and virtual training technologies, we could not identify the training development resources TRADOC would need to develop quality training content to support the use of these technologies.

We used available data (on nonsystem LVC technologies) to document a trend of decreasing investment in RDA budgets in POM 06–11 (see Figure 11.2). The figure shows a significant reduction in RDA funding between FY06 and FY11. The drop is largest in the case of virtual simulations, but it is also significant for constructive simulations and live training. Combined with our funding shortages as described in the preceding chapters, the downward trend suggests both a difficulty in obtaining full funding for accepted systems (perhaps due to a slow maturation of complex and demanding requirements) as well as difficulty in getting some new ideas initially recognized as programs of record. Moreover, these results suggest a potential imbalance in expenditures for operational technologies (which do not show the same downward trend) in relation to training technologies.

Army Process for Making Investment Tradeoffs

Another aspect of our approach to assessing the balance of current training enhancements was to examine the Army's current process for supporting strategic investment decisions. The completeness and

Figure 11.2
Trends in RDA Funding for Nonsystem TADSS, POM 06–11



RAND *MG538-11.2*

accuracy of the information available to this process, as well as leverage within the process to affect the balance of training enhancement investment, will help forecast the Army's likely success in making cost-effective tradeoffs.

The most visible decisions about prioritization of investments in training enhancements currently come from the Army's evolving Training Support System (TSS). The goal of the TSS is to provide a "system of systems" that seeks to provide an integrated training support capability and investment strategy that is synchronized with warfighter needs. It covers a substantial portion of training modernization activities, including live training transformation, and many of the larger constructive and virtual simulations. It supports the provision of funds for TADSS, for building and equipping home station ranges, and for modernizing the CTCs. Moreover, it encompasses not only new training technologies, but also the personnel and facilities needed to operate and house these capabilities. In addition, TSS includes funding for the sustaining capability to maintain and update fielded training systems and training products (e.g., TSPs) and an information infrastructure to support other initiatives. All outputs are linked with architectures and standards that seek to enable interconnectivity and interoperability among the pieces. Thus, the TSS focuses both on the functional capability of a range of individual training products and services, and also on supporting the interrelationships of all training systems within the system of systems.[7]

As a tool to support strategic investment decisions during an extensive period of transformation, the TSS offers the potential for the Army to evolve a process that covers many of the training enhancement areas. The lead for managing the execution of the TSS is the U.S. Army Training Support Center (ATSC); oversight resides with Department of the Army (DA) G-3/-5/-7, which manages resources and the priorities for resources across systems. In its annual review process, the Army Training Support Center facilitates a focused TSS review forum

[7] Of course, many large blocks of training resources are not funded under the TSS process. For example, OPTEMPO and the development of much training content are funded separately.

among all proponents with the aim of evolving an efficient, integrated, and highly relevant investment strategy. Participants in the review forum include TRADOC school leaders, user representatives, program executive officers (PEOs) and program managers (PMs), other DA staff (i.e., from G-8), and training and combat developers. The reviews have four levels of management oversight, capped by a Training and Leader Development General Officer Steering Committee (GOSC).

This process ultimately leads to decisions on the funding of many of the training enhancements to support force readiness. TSS reviews package training input to the POM by programs with clearly defined Management Decision Evaluation Package (MDEP) relationships. It also allows the Army to demonstrate requirements for support across three program evaluation groups (PEGs)—training, equipping, and installations—in the budgeting process. Besides affecting long-term funding in the POM, reviews support requests for quick-turnaround analyses during the period a POM is being constructed.

Given the forecast of tightening Army budgets, this initiative has the potential to play an even more critical role in the future. The training system must change to effectively support new and changing requirements, and scarce resources must be used in the most effective ways possible to adapt to these changes. Our research into the TSS initiative suggests directions for improvement in information flows, analytic capability, and some of the processes to affect change:

The TSS initiative could benefit from more complete and accurate information about the number and type of training events to be supported. The TSS initiative currently uses CATS strategies as a basis to define the number and types of training events to be supported. Yet this report has documented a substantial difference between the number and type of events units have been conducting and those outlined in these strategies. An unrealistic listing of events could lead to suboptimal investments in support capabilities; for example, support could be provided for events that do not take place, or not provided for events that do take place.

Perhaps more importantly, the use of CATS information in the TSS process suggests that it would benefit from a greater customer focus. Assuming a greater capacity to execute training events than is, in fact, possible suggests that constraints on unit time are not fully considered and addressed in current planning for enhancements.

The TSS process could benefit from the use of metrics to support a comparative analysis of the relative benefits of various (and different combinations of) training enhancements. The TSS process is still developing, and does not currently involve a formal set of metrics to support such an analysis. Because we could find no existing output metrics, we found it necessary to form qualitative "quality, quantity, and adaptability" metrics to reach our study goals. However, a set of metrics of this sort would be completely consistent with the current TSS strategic plan, which emphasizes a "systematic approach to performance measurement and appropriate metrics."

On the cost side, the TSS process could use more mechanisms to facilitate comparative cost analyses among related training support systems. For example, it is currently difficult to compare and integrate "system" training expenditures (i.e., those associated with a specific system and funded by its program manager) with "nonsystem" expenditures (i.e., those not associated with a specific system, and funded by general training funds). The TSS process does not always have good visibility of training funds controlled by program managers, and program managers, who are responsible for production of entire systems, do not always give their highest priority to training. However, underinvestment in "systems" training can lead to increased unit training requirements that eventually require more funding from general training budget categories.

The capability for comparative cost analysis is also hindered by an inability to identify all complementary resources, potentially leading to suboptimal investments. For example, the development of a constructive simulation could imply a corresponding need for an increase in resources in other MDEPs for scenario development resources. Without a mechanism to associate the required training development resources with the simulation, the true cost of the simulation can be underestimated (and the benefits overestimated), relative to other systems. If those resources are not ultimately provided, the system may provide less than its potential capability when developed.

The TSS process would benefit from a greater capability to cross-level resources. The TSS process is also subject to certain difficulties in transferring funds between enhancement categories, even when it can be shown that the transfer would benefit the overall balance of training support investment. For example, the TSS review process cannot easily affect system training expenditures, even if those expenditures can be shown to be out of balance in the larger picture. Also, because resources do not routinely transfer between PEGs, it would be difficult within the context of the TSS process to correct an imbalance (as was noted in the context of battle command training) between training support manpower and evolving technologies. While some of the training support manpower is funded under the TSS program, other manpower is funded through OPTEMPO funds, the manning PEG, or the NET program.

Thus, we find that the Army's capability to make strategic resourcing decisions concerning training enhancements is constrained. The process does not receive complete information on its ultimate customers. Further, in conducting analyses, it is difficult to identify all the benefits and costs and to identify some of the key supporting resources within enhancement categories. Finally, when imbalances are noted, it can be difficult to make adjustments across programming categories.

Conclusions

Our integrated assessment of enhancements leads to the following conclusions:

- In the face of challenging operational requirements, the planned enhancements as a whole provide important improvements for the training system across a wide spectrum. Further, while the amount varies greatly, all enhancements provide some potential benefit. Of particular note is the degree to which the enhancements focus on technology with large potential payoffs in the long term.

- At the same time, we found no "silver bullet" among the enhancements that would revolutionize training strategies for BCTs within the 2016 timeframe. Indeed, the study concluded that live training will remain the cornerstone of FCS-equipped BCT training programs, even though there is limited potential for increasing the amount of this type of training. This conclusion implies that live training enhancements (such as CTC modernization, home station improvements, and an ETC) remain critical and deserve continued emphasis.
- Despite continuing improvements to the training system and adaptations made by unit leaders and trainers, we find that, in the 2016 timeframe, the training capability achieved under currently planned enhancements is likely to remain substantially less than that needed to fully meet future training requirements, especially those generated by the COE. This assessment is made relative to what the training system was able to achieve prior to 2002, before recent deployments. The gap in achievements relative to requirements reflects both how difficult new training requirements are and how high the prior standard was.
- We also conclude that some further shaping and balancing of enhancements could likely improve overall benefits and reduce the gap prior to 2016. The idea that further shaping might improve benefits stems from the following observations:
  - The area of leader training exercises used to train battle command represents the Army's best chance for significant near-term improvement in the training strategy within the 2016 timeframe. Pursuit of this goal could potentially lead to significant improvements not only in training quality, but also in the quantity of events and the adaptability of the training system. However, a greater emphasis on training manpower support relative to training technologies is likely needed to pro-

duce a large improvement in overall benefits. More generally, we found a tendency to overestimate what training technologies could accomplish,[8] especially relative to less technological and more traditional means of adding support.

– We found what appeared to be some imbalances in what training enhancements were trying to accomplish. For example, we noted that while many enhancements appeared geared toward improving the quality of training, fewer seemed aimed at increasing the quantity of training or producing greater training event adaptability. Moreover, much of this imbalance seemed to derive from an inadequate consideration of key training system constraints, especially limitations in unit leader time.
– We found that the TSS process is somewhat constrained in the information it has available, its analytic capability, and its ability to cross-level resources (see further discussion in bullet below). We believe that more information and better capabilities would have changed its ultimate decisions.

- Successful evolution of the TSS process to identify and defend the most important enablers will be key to the Army's success in making effective use of training dollars. The process the Army currently uses to select, fund, and prioritize training enhancements would benefit from more feedback from units on their current training programs and constraints, and a greater evaluative capability (including effective training metrics) to assess relative costs and benefits across enhancement categories. More mechanisms might also be needed to effect changes in investment strategies once imbalances are discovered.

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[8] This tendency is fostered by overly optimistic requirements documents and by a programming process that demands interim results to ensure continued funding. For example, in the FCS program there is an assumption that OPTEMPO can be reduced by half (from 800 miles to 400 miles) because of embedded training (ET). We see no justification for this assumption. ET will add to training opportunities, especially for individual and crew training, but it is not likely to replace live collective training in any meaningful way for the foreseeable future.

CHAPTER TWELVE

Recommendations

In this chapter we present recommendations for action with regard to the training system, focusing on actions that UAMBL could implement directly or help champion. Previous chapters illustrated how the COE and ARFORGEN, together with modularization, modernization, and other organizational changes, have affected training requirements. The study evaluated a range of enhancements under way or proposed by the Army to address changing requirements and to improve the training strategy for BCTs equipped with FCS systems in the 2010–2016 timeframe. The benefit of each enhancement was measured in relation to its ability to improve training quality, to address the increased quantity of training events required, and to improve training system adaptability.

The recommendations presented in this chapter are designed to address the key conclusions reached from this research process, especially those derived from our integrated assessment of all enhancement categories (see Chapter Eleven).

Recommendations for Effecting Critical Training System Improvements

Despite the challenges faced by the Army's training community, we see possibilities for significant gains in the present environment. To achieve these gains, UAMBL (and the Army) should consider several initiatives.

More Closely Monitor and Manage the Program to Develop Training Strategies for BCTs Equipped with FCS Technologies

Certain actions will increase the likelihood of achieving critical training system improvements in the 2016 timeframe. We recommend the following.

- Implement a series of metrics aimed at measuring likely quality, quantity, and adaptability improvements in training; these metrics could be used for the training Key Performance Parameters in FCS and other requirements documents.
- More closely monitor existing Key Complementary Programs for the FCS, and add at least two new ones: the BCTC, and TRADOC capability to produce training content.
- Establish a clear and realistic basis for making assumptions about the level of benefit to be provided by the enhancements. In the past, such assumptions have sometimes been overly optimistic. For example, the FCS program currently assumes, without a clear basis, that ET will allow a 50 percent reduction in the miles-based OPTEMPO resources required for live training.
- Work to obtain or protect critical resources needed to support training enhancements. These resources include:
  - Embedded operator and crew trainers and tutorials. Closely monitor the FCS program to ensure that it gets maximum capability as early as possible.
  - Training manpower support resources. Ensure sufficient manpower resources for the BCTC to support ARFORGEN training requirements and support a spiral development process.
  - New operator/maintainer training. To protect BCTC resources, work to obtain a new NET-like capability for new operator/maintainer training at reset/train for FCS-equipped BCTs.
  - Other resources need to support training deriving from Army modernization, including the spiral-outs. These include appropriate TESS support for new systems, changes in simulations to incorporate new systems, and support for training capability in the area of C4ISR training methods and means (see Chapter Eleven for an explanation of these items).

Continue to Shape Enhancements Within Available Resources

Given the expected gap we identified between training requirements and training system improvements, the key challenge for the Army is to select and implement enhancements that provide the most benefit given the likelihood of considerably constrained training resources. For example, in the context of the continued importance of live training enhancements and their relatively high cost, it will be important to prioritize those resources, such as MOUT facilities, that best support adaptation to meet changing requirements.

The challenge of selecting enhancements with the highest payoffs must be met in the presence of large uncertainties. In addition to the changing nature of requirements, the ongoing evolution of Army transformation makes predicting the effects of transformational initiatives (i.e., modernization, modularity, lifecycle manning) on training and readiness requirements an uncertain and ambiguous process. Further, because training (as well as operational) technologies are being developed in the presence of significant technical risks, synchronized tradeoff decisions involving capabilities, costs, and fielding need to be made on an ongoing basis (e.g., when the enhancements go to initial operational testing and evaluation (IOTE)).

To increase the benefits of the enhancements as a whole, we recommend that the Army undertake new spiral development processes to implement TSS initiatives and to effectively evolve training capabilities. Spiral development includes continual observation, assessment, and analysis. Endorsed by DoD as the way to build the future training environment, the spiral development process has been described as the "build a little, test a little" approach.[1] If aggressively pursued, spiral development can produce significant benefits from promising training methods and products even when large uncertainties exist.

Greater customer input and increased analytic capability would facilitate a more formalized spiral development process. The process would start with an acquisition and evaluation roadmap associated with each training enhancement designed to provide a basis for rec-

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[1] Department of Defense Training Transformation Implementation Plan, June 9, 2002, pp. 5–6.

ommending updates and changes to programs as they develop. The roadmap would include an evaluation of enhancements during the development phase, as well as longitudinal studies providing feedback from the field on their ongoing impact in later phases. Greater analytic capability would include evolving improved metrics to develop Training Support System priorities. The metrics would include (1) metrics related to the effect of the enhancements on the quality, quantity, and adaptability of training; (2) cost metrics that facilitate identification of the full costs of given capabilities, and (3) field performance metrics that measure the effect of the enhancement and training on actual unit performance.

As an initial step, we recommend a spiral development process to evolve training capabilities in the area of battle command training. While this improved capability would be supported by constructive simulations, the key to the proposal is to increase and better organize training support manpower to take full advantage of the constructive technologies. Appendix C suggests activities that would be involved in a spiral development process for simulation-based training. We see this as the Army's best chance for significant near-term improvement in the training strategy within the 2010–2016 timeframe.

Greater training manpower support might benefit other areas as well. For example, greater training manpower support might allow Range Control organizations to provide more Range Support capability. In general, we believe initiatives that directly support the capability of commanders to plan, prepare, and execute training events given time constraints should receive a higher priority.

Other investigations might also help to better balance training enhancements. For example, training enhancements currently emphasize new technologies with large potential payoffs in the longer term. The Army might balance this emphasis by increasing its focus on potentially high-benefit TADSS enhancements that best meet COE needs[2] but that are also lower risk, involve shorter timelines, and require more

[2] For example, capabilities to train tank crews to engage with close-in dismounted targets may deserve greater emphasis relative to enhancements to train crews for longer-range tank-on-tank engagements.

modest investments. An example of this kind of rebalancing would be the systematic examination and development of low-overhead leader tactical skills trainers (see Chapter Eight).

Wider Implications

Need for Integrated Funding Strategy

Our analysis of the adequacy and balance of training system enhancements was hampered because we were able to achieve only a partial mapping of budget categories into the various enhancements that we identified. While further analysis could have achieved a more complete mapping, we believe there are structural impediments within the programming and budgeting process that make it especially difficult to identify all the resources relevant to any given training capability, particularly those being developed for future systems. The same impediments also work against achieving an integrated and balanced training strategy. For example, there is not yet an adequate vehicle for ensuring integrated expenditures between "system" and "nonsystem" TADSS or among the program evaluation groups. This, in turn, impedes the Army's ability to formulate a tight, logical, and defendable argument for obtaining and maintaining required resources for the training strategy. Defending the program, convincingly describing the impact of funding shortfalls, and even simply informing senior leaders are all made more difficult as a result.

Visibility of the costs and benefits of training initiatives and integration of investments across all the initiatives will be especially important in the future. The Army is faced with a situation in which it may not be able to achieve all its training goals and will need to make tradeoffs and seek balance in order to maximize what it can achieve within the resources available. As a first order of business, the Army should strive to obtain financial information across the training enhancement categories described in this report. Forming "capability modules" in the financial process to correspond to the enhancements identified in this report would allow integration of the total training program across the Program Evaluation Groups (PEGs) and allow the balancing of capabilities across programs. This does not necessarily mean creating MDEPs to correspond to the enhancement categories. For example, it may be possible, using a data element in the Program Optimization and Budget Evaluation (PROBE) database, to simply "tag" some or all of the resources relating to capability categories within the existing MDEP structure.

Trading Off Operational Capability with Training Capability

Our assessment of training enhancements in relation to the Army's high goals for what it wants to achieve in training and readiness programs leads to the conclusion that potential gains for the training strategy are limited by the relatively modest potential for increasing funding for training. While we believe there are some opportunities to better balance the planned training initiatives within existing resource levels, our suggestions for improvement also imply the need for increased resources to enable a more expansive training strategy. History suggests that training, in general, is underfunded in relation to operational capacity.[3] Moreover, in this report we documented a trend of decreasing support in RDA budgets in POM 06–11 (see Chapter Eleven). Without sufficient investments in training support, the Army is likely to have units that cannot fully capitalize on the capabilities of FCS modernization because they are not fully trained. Moreover, our examination of the implications of COE suggests that training improvement may be the most cost-effective means of achieving increased future operational capabilities. Thus we see the need for a training resource strategy that goes further than integrating funding among existing training programs. The training resource strategy should also be integrated with the FCS-equipped BCT programs and Army Transformation as a whole to get the right balance of resources between operational capacity and training.

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[3] For example, see Dr. Ralph Chatham and Dr. Joe Braddock, Co-Chairmen, *Training Superiority and Training Surprise: Final Report,* Defense Science Board Task Force, 2002.

APPENDIX A

Method Used to Score Unit Performance at the National Training Center (NTC)

In this appendix we describe the method used to score unit performance at the NTC. The findings from this analysis are found in Chapter Three.

Table A.1 illustrates how units were scored. All questionnaires use a six-point rating scale explained in the table.

Scores are based on whether the skill, task, or function was accomplished well enough to allow mission accomplishment, independent of other performance or actual mission accomplishment. In other words, performance on each skill is measured against the Army standard, and not on whether or not the unit succeeded. This means that a unit may not completely accomplish its overall mission, even though it may have performed some skills so well that it could have accomplished its mission had other tasks been performed better. For example, a tank company might not have engaged the enemy effectively with direct fire and would get a "1" ("Not Sufficient") for this skill. However, the same company might have used proper movement techniques and thus received a "4" ("Completely Sufficient") for the movement skill.

Researchers also record the percentage of units that show improvement between first score and best score (in cases in which skills were practiced more than once). These data show outcomes from the types of training programs that unit commanders were able to implement to develop a major combat operation (MCO) capability in a period with less demanding operational and modernization requirements than faced today. Thus, we believe that whatever shortcomings units showed in this period are likely to be important areas to consider in developing improved training strategies.

Table A.1
Scores and Ratings for CTC Data Questionnaires

Score	Rating
~~0 1 2 3 4 5~~	Not applicable or not observed
0	Not done, but should have been
1	Not sufficient
2	Somewhat sufficient
3	Moderately sufficient
4	Completely sufficient—the action or activity was complete and timely enough so that the assigned tasks or missions could be accomplished
5	Superior

~~0 1 2 3 4 5~~: Not applicable or not observed. If the action or activity was not appropriate (i.e., not necessary) for this operation or was not observed during the course of the exercise, then all numerical values are lined through.

0: Not done, but should have been. The action or activity was *not done* but should have been done.

1: Not sufficient. The action or activity was accomplished but was *so incomplete* or poorly done as to be ineffective.

2: Somewhat sufficient. The action or activity was accomplished and was *partially* complete or done in a partially effective manner.

3: Moderately sufficient. The action or activity was accomplished and was *moderately* complete or done in a moderately effective manner.

4: Completely sufficient. The action or activity was *complete* and *timely* enough so that the assigned tasks or missions could be accomplished.

5: Superior.

APPENDIX B

Approaches for Developing Effective Simulations and Automated Support Training Tools

This appendix provides additional information relevant to the development of constructive simulations-supported training for battle command skills, as discussed in Chapter Ten.

Aspects of Simulations and Approaches to Rapid Improvement

There are a number of areas in which constructive simulations could be improved in the 2016 timeframe to provide more events, events with higher quality, and better-adapted training for the BCTC and BCTP. First, there are some important questions regarding the level of realism required for constructive training events to provide "good enough" realism for training battle command skills for the COE and MOUT operations. There are many aspects of current (BBS, JANUS, JCATS) and future (OneSAF and WARSIM) simulations that are being considered for improvement, or have specifications in their design documents to have their realism improved.

To help inform the question of "how realistic is good enough," there should be immediate emphasis in the Army and related research communities in the area of costs and benefits of realism in simulation-supported training. More rigorous studies such as that recently published by the Army Research Institute (ARI) on the effectiveness of game-like simulations[1] are urgently needed to help guide where time, dollars, and development emphasis are targeted. For example, for MOUT training, what is the value of having more realistically rendered weather effects? Is the value higher or lower for other training?

Another important area that needs to be informed by research is the fidelity or "grain size" that a simulation must operate at in order to provide the training audience with the realistic feedback needed to identify and improve performance. Clearly this does not mean that the behavior of each individual in a battalion operation must be simulated to be "real enough" for adequate performance feedback. But how about each squad? Each platoon? Where is the line,[2] and how does that line influence the learning that the training audience experiences? Insights into the answers to these questions can be gained by a well-designed research effort.

There are general tactics that can speed the process of developing, testing, and deploying simulation improvements that will be key to stability, dismounted, MOUT, and other COE-type operations. These methods can include an intensive, "Tiger Team"–like effort to define the priorities for improvements or new simulation features with heavy input from the trainers themselves, commanders returning from deployments, and CALL staff. This list of changed/new features then needs to be ranked by importance and difficulty of implementation, and implemented accordingly. Another suggestion is to engage in software development practices from industry that emphasize rapid prototyping and iterative design-test-revise cycles, as outlined in earlier research.[3] Methods such as Extreme Programming[4] are being used by major U.S. corporations to speed the development cycle for certain applications and saving large amounts of time. Simulation development for training purposes is a good candidate for such methods because this soft-

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1 Scott Beal, *Using Games for Training Dismounted Light Infantry Leaders: Emergent Questions and Lessons Learned,* ARI Research Report 1841, September 2005.

2 Does the line cross from "entity-based" to "force-ratio" models to simulate interactions between forces?

3 Shanley et al. (2005), Chapter 3.

4 www.extremeprogramming.org

ware development can be done relatively quickly. Moreover, users can get hands-on, rapid feedback on the perceived value of the changes to trainers and learners.

Simulations Support Tools to Improve Constructive Command and Battle Staff Training

Various tools to support the planning, development, execution, analysis, and AARs for constructive training could be evolved.

Scenario Development Tools

Even basic methods for searching for and sharing scenarios via networks would provide improvements over current practices using scenarios that are developed for one's unit the last time it was trained. Once a scenario approximating the one desired is located, having some basic, user-friendly authoring tools could provide some decrease in authoring time. The goal would be to give either unit or simulation center staff the ability to adapt the scenario in some basic ways (e.g., loading a different TOE, moving the starting positions of various BLUFOR or OPFOR units).

The requirement for such tools should preclude the necessity for any programming expertise and minimal training on using the basic tool. Given the directions that OneSAF is taking, it would seem prudent to build such authoring tools based on software tools with which people are already familiar, such as an interface like that of PowerPoint. Note that such tools (of varying ease of use) are regularly made available by software companies selling games as a way to increase use/sales of the game later in the game's product lifecycle.

"Modification tool kits" (called "modding tools") are basically versions of standard software development kits for other applications. These tools provide members of the user community with the ability to create new scenarios, develop new terrain, create new weapons, etc. Clearly there are some aspects of such community development that might be appropriate for Army training applications. This is an area in which the Army could start experimenting immediately to begin to address the many questions that must be faced when decentralizing scenario/curriculum development.

For example, who provides quality assurance of user-developed scenarios? What features of the simulations should and should not be modifiable? What kinds of security, if any, should there be on who has access to the scenarios? If the goal is to provide tools that make scenarios easier to find and develop/tailor, we highly recommend beginning the process immediately through experimentation and lessons learned instead of a lengthy process of design, development, deployment, and revision. We are recommending the use of rapid-development methods for this area of innovation.

Execution Management Tools

Being able to start, run, stop, rewind, and restart simulation-based training is a clear requirement for effectively running training events. Current simulations require significant expertise from event support staff to carry out these tasks. Providing capabilities and tools to execute such actions would not only speed the process of managing the training event, it would also "de-skill" the tasks to be available to staff who do not have deep, simulation-specific knowledge or programming expertise. This, in turn, also increases the deployability of the management aspect of conducting training events. Developing and fielding such tools is well within the expertise of software developers.

AAR-Material Generation Tools

Within the 2016 timeframe, the Army will not benefit greatly from having artificial intelligence to aid with the process of capturing data for AARs or developing AAR materials. However, there can be significant progress in the development of automated data logging, analysis, and development of basic libraries of briefing slides (in PowerPoint format) to reduce workloads on the human trainers. The OCs at the NTC have standard libraries of AAR slides that they can draw from, populate with data from the event (by hand), and use in AARs. Having parts of such libraries automatically developed for OCs of constructive events will still not replace the need for intelligent OC identification of learning moments and AAR preparation, but it will provide some amount of time savings if they want to use automatically generated slides as part of their presentations. The ability to generate such capabilities is well within the realm of current development and could provide limited decreases in AAR preparation time for already overworked OC teams.

Note that in the cases of all such tools, we strongly recommend that separate cases for different simulations should be initially developed independently for individual constructive simulations instead of waiting for the maturation of "common tools." The rationale is that the Army training community does not yet know enough about what makes successful tools to start generalizing those tools. Building multiple versions of such tools for different simulations is not cost-efficient, but it does provide development of a variation of tools and lessons to be learned. Once there are some examples of successful tools, then the Army can either begin the process of selecting a "best of breed" or work on building cross-simulation, common tools.

APPENDIX C

Activities That Could Support an Improved Spiral Development Process for Simulation-Based Training

This appendix describes a number of activities the Army could support to achieve the potential of simulation-supported training to play a significant role in current and future BCT training (in the 2016 timeframe).

Demonstrate positive transfer from simulation-supported training to live actions. Without understanding the strengths and weaknesses of simulation-supported training, it will continue to be difficult to:

- Understand where to apply the technology most cost-effectively.
- Provide compelling rationales for appropriate financial and human support to realize the benefits.

There is work from the sports world that suggests positive transfer of virtual tasks to physical tasks, and interesting work planned at ARI to explore differences in transfer of training based on 3D, head-mounted displays versus flat panel displays.[1] However, there are widely varying opinions, expressed informally, on the potential value of simulation-supported training to teach crawl- and walk-level skills relevant to MOUT and SOSO. There is a strong need to provide evidence of

[1] This ARI study had yet to be funded at the time of this report.

the areas in which such training can provide training value for close combat/SOSO operations for small, dismounted teams.

Understand how to speed simulation exercise development and improve the quality of outcomes. The Army must do studies to understand how to overcome the barriers of preparation time to design, set up, and control the activities during the training run of a scenario. This goal should be pursued via detailed studies by third parties of the tasks carried out, the tools required, and experiments with prototype tools. This will inform the magnitude of cost and time savings, as well as help to increase effectiveness.

Explore methods and costs to provide high-quality OPFOR for simulation-supported training. There is a clear need for realistic, high-quality OPFOR and other simulated stakeholders in current operations (civilians, government employees, local leaders, NGO workers, etc.). Given the current and 2016 limitations on benefits from artificial intelligence for SAF, described earlier, automated entities will only be able to provide intelligence to support the very basics of crawl-level training. Such training will require human role players to achieve "walk-level" training. These role players could come from nontraditional sources. This includes exploring the use of:

- Trained Army reservists and Reserve Officer Training Corps (ROTC) personnel.
- Trained public, volunteer labor resources to provide human role players for virtual simulation-supported training. There is a very large number of people currently regularly engaging in on-line, "first person action" games via the Internet. The Army should investigate the costs and benefits of possibly taking advantage of this large pool of active hobbyists as virtual role players (as simulated insurgents, Iraqi villagers, local Afghani officials, etc.). Although there are many unanswered questions regarding measuring and qualifying such role players on the quality/fidelity of their behaviors and the resulting training, the large potential benefit of leveraging this potentially low-cost resource suggests that close investigation might pay off well.

Increase the value of automated instruction during and following simulation-supported training via automated data collection and tailorable AAR capabilities. Increased resources should be allocated to support the study and development of AAR capabilities that can provide constructive feedback similar to that provided by OCs. There should be emphasis placed on the development of automated data collection to allow continuous collection of data on usage and outcomes as a corpus of data for formal evaluation work by third parties.

Support development of small-scale simulation-supported training at the institution level, as well as at the PEO STRI level. As the costs of developing simulation-supported training continue to drop (a dollar cost of basic programming environment and a decrease in the skill level needed to program) and the power of these tools continues to increase, there will be increasingly many applications for small-scale, short-term development and use of simulation-based training. For example, there could be many cost-effective cases where a school should consider building appropriately verified, validated, and accredited simulation-supported training for tasks that are not Army-wide and require:

- Fast development and deployment, e.g., teaching new manual methods for disarming land mines or ordnance.
- The development of complex individual and collective skills that require dynamic practice, e.g., teaching managers of theater-level logistics pipelines to predict and proactively avoid bottlenecks and shortages. These could be virtual or constructive simulations.

The concept behind this recommendation is to move the development of these systems as close as possible to the training audience and sites of domain expertise, and use rapid-development methods. This minimizes delays in production and needs for temporary duty (TDY) costs for subject matter experts. Examples of this model of production have arisen at a number of Army schools for various training products.[2]

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[2] A "Virtual Motor Pool" to train armor maintainers is under development at the Armor Center, Fort Knox, KY.

The limiting case of this type of training is to think of such simulation-supported training as having short lifecycles and being "disposable." Such applications would be quickly developed and useful for a short period of time to train/educate a specific skill[3] that might be needed only for specific conditions of a single deployment.

[3] E.g., diagnosing and repairing specific problems with Reverse Osmosis Water Purification filter systems under specific deployment conditions.

APPENDIX D

Using Constructive Simulations to Improve the Army's Capability for Battle Command Training

The FCS BCT training concepts outlined in the FCS O&O Plan and the FCS STRAP envision a considerable contribution from an embedded constructive simulations capability. This embedded capability is expected to aid in operational planning and preparation and to significantly increase the quality, quantity, and adaptability of constructive simulations-based training events for commanders and battle staffs. Explicit in these plans is a provision to increase the quality and adaptability of training sufficiently to achieve frequent "run-level" battle command training events and effective operational mission rehearsals.

The Army has established a goal of improving its capability to train brigade and battalion commanders and staff in battle command skills. While this is surely a desirable goal, the analysis presented in this study indicates that it will be difficult to achieve major improvements in this area by 2016 via currently planned constructive simulations enhancements. Supplementing the capabilities of constructive-supported command and battle staff training by other means will go a long way toward meeting the challenge.

In this appendix we explain why we estimate the potential for constructive simulation-supported exercises to be high, what improvements beyond the currently planned enhancements are needed in this type of training, and how the Army could evolve current programs to capitalize on the potential of constructive simulation-supported training.

Why the Potential for Improving Constructive Simulations-Based Training Is High

Battle command skills are key to effective implementation of current and future operational concepts. FM 3-0, *Operations,* which establishes the Army's keystone doctrine for full-spectrum operations, allocates a chapter to this aspect of Army capabilities.[1] Battle command is defined as "the exercise of command in operations against a thinking enemy" and as "an art that employs skills developed by professional study, constant practice, and considered judgment." The FM explains that "Commanders, assisted by the staff, visualize the operation, describe it in terms of intent and guidance, and direct the actions of subordinates within their intent. Commanders direct operations in terms of the battlefield operating systems." Battle command is a complex function, all the more so considering the complexities of the COE and the range and technological sophistication of C4ISR, lethal, and nonlethal systems available to the FCS BCT.

Battle command skills are also difficult to master. Evidence from previous research on how well battle command skills are executed at the CTCs[2] strongly suggests that while units improve in their ability to execute complex tasks and subtasks over the course of a CTC rotation, many units do not fully master many battle command associated skills. Mastery of these skills, i.e., run-level expertise, requires continual realistic practice in a complex operating environment and under a wide range of conditions. The wide range of conditions helps maneuver commanders and staff to develop "intuition"[3] and learn to adapt quickly and effectively.

While live training will remain the cornerstone of future training, the number of battalion and live collective events possible will remain limited. Under the ARFORGEN strategy, a BCT will get two

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1 There is also an FM devoted to battle command skills, FM 6-0, *Mission Oriented Command and Control*.

2 Contained in an unpublished RAND report by B. Hallmark et al. on using CTC data as a tool for assessing training.

3 Klein (1998, 2003).

CTC or "CTC-like" events during its three-year lifecycle. Achieving the full complexity and realism needed for successful higher-echelon live training events will be even more difficult at home station, due to limits on resources.[4] Thus, neither CTC rotations nor live battalion- and brigade-level exercises are likely to increase the overall *quantity* of training in battle command skills. This suggests that other methods are needed to provide the desired frequency and scenario breadth to develop and maintain battle command expertise.

For several reasons, we think that the highest potential for improving the Army's training strategy lies in better leveraging constructive simulations for battle command training. Properly supported constructive exercises offer the potential for far more iterations across a greater range of conditions, while still providing direct performance feedback. Thus, constructive exercises provide an opportunity to significantly increase the *quantity* of training, allowing leaders and staff to engage in a greater frequency of realistic practice than would be possible relying only on live training. In this manner the Army will be able to add to the development of sophisticated battle command skills, including synchronization. Training against the wider range of conditions made possible by constructive simulations could also help to promote adaptability. Moreover, the capability to embed simulations for battle command training into operational equipment is much closer to being technologically feasible for constructive simulations (compared to virtual simulations). Thus, it makes sense to focus some battle command training efforts in the constructive area.[5]

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4 We think "wrap-around" will add realism and complexity to live training at home station, but we think this essentially involves using constructive simulation capabilities to create these conditions to the live training audience.

5 We realize that virtual simulations at some level of capability will also be embedded as the FCS vehicle weapon systems are initially fielded. However, as discussed in Chapter Seven, there is significant risk that these technologies will not deliver as anticipated, or will take longer to deliver. Also, the likely limitations of the virtual replication of the large number of entities beyond vehicle-based weapon systems required for battalion and brigade echelon events mean that even when virtual simulations are used, they will essentially be based on constructive simulations.

Constructive simulations-supported training is also well suited to training battalion and brigade commanders and their staffs to employ C4ISR technologies effectively, and this is a key need for leveraging FCS capabilities. Constructive simulations provide an effective means of assisting commanders and staffs to use ABCS and ISR systems.

However, despite these advantages, the high potential of constructive simulations is not currently being realized. Indeed, units report that the current simulations are rarely used. One reason is the large workload and high level of expertise needed to plan, prepare, and execute a constructive simulations event, especially the large amount of time required for unit leaders. Another reason is the difficulty of adapting simulation events to the specific needs of the unit, both during the setup of the scenario and during the event itself. Finally, and most importantly, current simulations lack use because the users do not believe they provide sufficient levels of realism and complexity, especially considering the COE.

Realism requires that the training audience perform the full range of tasks that would be required for an actual operation, and the performance of these tasks should have the same types of difficulty, and the same effects, as would be found in the real world. To cite a few examples of what realism and complexity involve:

- To achieve adequate realism, the operational results of the simulation must reflect likely operational outcomes given the conditions. For example, the movement of a unit along a route should be within a range that would be likely for an actual unit given the equipment, terrain, weather, and tactical situation. Similarly, lethal and nonlethal effects and the detection capabilities of ISR systems should mirror those of the actual operational environments.
- Realism also requires randomness—the "fog and friction of war"—which would be the case in an actual operation. For example, during the course of an operation, the movement rates should vary, even for the same unit under the same conditions. Other random events include lost communications and maintenance breakdowns.

- The outcomes of the training audience's actions must also be reasonable and should support an understanding of the link between cause and effect. Such an understanding will facilitate AAR processes. For example, if an order is not given in a timely enough manner, the result should be some degradation of any constructively simulated subordinate unit's actions.[6]

Constructive simulations-supported training of command and battle staff skills is a clear option for providing more frequent and more variable training events. However, achieving the full potential of this tool will require several challenges to be overcome, as discussed in the next section.

Addressing the Challenges to Improving the Quality and Quantity of Constructive Simulations Training

The key to meeting the challenges of unit workload and limited realism is placing a high priority on a structured effort to improve the ability of constructive simulations exercises to support battle command training. This effort should incorporate the following components:

- **Provide sufficient training support manpower** to support units' efforts to plan, prepare, and execute constructive simulations and thus take much of the burden off unit leaders.
- **Formalize effective training methods** for constructive-supported battle staff training.
- **Develop an effective program to train the trainers of simulation-based events** to plan, prepare, and conduct battle command exercises driven by constructive simulations.
- **Improve simulations capabilities**, including for LVC-IA and SAF.

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[6] For example, in many current simulations a company commander can react to fragmentary orders from a battalion commander and move his platoons far more quickly in the simulated environment than in an actual operational environment.

- **Develop effective training support tools**, including scenario authoring, exercise management, and automated data logging and analysis to support AARs.

As described in previous chapters, major efforts are currently under way to improve the technical capabilities of simulations (WARSIM and OneSAF), integration of simulations and operational ABCS (LVC-IA), and supporting technology tools (e.g., for scenario development and supporting AARs). While these efforts are useful, we believe the key to improving the effectiveness of events based on constructive simulations in the 2016 timeframe lies primarily in the first component listed above—training support manpower—and secondarily in the next two—the development of effective, efficient training methods, and the development of effective train-the-trainer programs.

Taken together, proper emphasis on these five components will allow the Army to realize improvements in the quantity, quality, and adaptability of constructive-supported training events for battle command skills in the near term. We think it important to leverage these initiatives into a synchronized program that uses spiral development techniques. Coordinated actions to accomplish this could well have payoffs not only in the near term (next 5 years), but also in the middle and longer terms.

Providing Sufficient Training Support Manpower

Because we think that the human part of the simulation-based training system is the key component in the 2016 timeframe, we see the Battle Command Training Center (BCTC) program as being the key initiative for improvement. Under this program, about 700 to 800 training and training support personnel are currently programmed to be available across 12 active component installations in the United States. The BCTC can use this staff both to conduct ABCS sustainment training and to support command and staff training exercises.

One challenge in this area is that while the BCTC offers a considerable increase over the current staffing allocated to the Battle Simulations Centers, the number is far short of matching the staffing of the Battle Command Training Program's brigade training team, or the number recommended for a brigade-level CPX in the Stryker BCT TSP. Later in this appendix, we discuss how the programmed BCTC staff might evolve in their role of supporting constructive simulations.

Another challenge is that competing training needs could potentially divert BCTC staff from the mission of supporting constructive events. In particular, under the ARFORGEN and lifecycle manning initiatives, there will be a large unit and MACOM requirement to train most of the operators and maintainers of an entire BCT in the first part of the "reset/train" phase.

While the exact size of the requirement will depend on the specifics of the implementation of those programs, the work could easily consume most of the BCTC's potential at an installation with multiple BCTs. Given the large number of systems in an FCS BCT, the required training throughput could be in the neighborhood of 1,000 soldiers.[7] Moreover, to meet the goals of attaining battalion-level training proficiency in 6–8 months, this basic operator training on ABCS-type and other new equipment will need to be completed prior to beginning platoon-level collective training, and this means that the training should be completed in the first month or two of the reset/train phase.

Under the Army's individual replacement system, the requirement to train new soldiers on equipment as they enter a unit is ongoing, relatively small, and easily handled by the more experienced staff that comprise the unit when the replacements arrive. In contrast, under lifecycle manning, the training requirement at the start of each three-year cycle approaches the magnitude of new equipment fielding, in which few experienced unit members will be available to train the inexperienced ones. In the case of new equipment fielding, initial operator training is performed by NET teams provided by system program managers (PMs). However, because much of the equipment in the reset/train period in ARFORGEN will not be new, there will not be any NET teams to train the large number of new operators. Given these considerations,

[7] The number of ABCS-like systems (the FCS BCTs will have advanced but different systems) in the FCS BCT is uncertain at this time. The current Army Digital Training Strategy recommends training an operator and backup operator for each system. Also, some soldiers will need to be trained on more than one system.

we think the Army should treat initial ABCS training at the start of the ARFORGEN cycle as requiring a NETT-like effort resourced by the PM, rather than leaving it as a unit/MACOM requirement. This would free much if not all of the BCTC capability to assist with ABCS sustainment training and to support battle command training.

Formalizing Effective Training Methods

Just as battle command is an art, the training of battle command skills to commanders and staff is also an art. Not only must trainers themselves be experts at battle command and its supporting skills, they must also have the training and teaching skills to:

- set up and conduct the exercises,
- observe and analyze the simulated "operations," and
- create and facilitate an effective AAR.

Moreover, in some respects it is more difficult to make a constructive simulation-supported exercise a realistic training event than it is for a live training event, because the training must be completed in the absence of actual units on the ground. Yet battlefield realism still requires that the event have elements such as "fog and friction" and complexity, and that it exercise all the tasks the training audience would require in an actual operation.

Currently, there is deep expertise in the BCTP for training methods, techniques, and procedures in a constructive training event. However, a key challenge in the future is to formalize effective and efficient training methods so that they might be available to more personnel. Our discussions indicate that outside the Functional Area (FA) 57 and Career Program (CP) 36 programs,[8] trainer techniques for effective simulation-based training events are only informally learned, and by relatively few people. For example, such skills are trained when there is informal dialogue between the Battle Simulations Center staffs, and when there is a sharing of activities within the FA 57 and CP 36

[8] FA 57 is the officer functional area specialty of modeling and simulation. CP 36 is the counterpart DA civilian field. www.fa-57.army.mil/newsletter/online/Fall2004/cp36.htm

programs. In the future, many more personnel, such as BCTC staff and unit leaders, will need to learn more of these methods in order to improve constructive command and battle staff training. Thus, we think that a more structured program to formalize and improve simulations training methods, techniques, and procedures would be of great benefit.

Developing an Effective Program to Train the Trainers of Simulation-Based Events

Related to the need to develop training methods to more efficiently and effectively support constructive simulation-based training of battle command skills is the need to develop more training expertise in trainers. A large number of qualified trainers, as well as unit and outside training support staff, are needed for high-quality battle command training. Hence, we think it is important for the Army to protect, and if possible expand, initiatives to build more simulation-based training expertise among its ranks.

The FA 57 and CP 36 career fields are evolving professional development programs across the broad area of simulations and modeling, but there are more specific needs for expert trainers. The BCTP runs internal training and experiential learning for its staff, and like the maneuver CTCs, these officers and NCOs can carry these lessons learned to the operational Army. However, given the difference in manning levels and greater use of contract personnel in BCTP, the diffusion of constructive simulation-based training expertise into the Army is much more limited than live training expertise from maneuver CTCs.

Likewise, there is limited training for simulation-based trainers in PME courses. Many of these courses include use of constructive simulations to train operational skills, but there is little curriculum emphasis on training the leader to use these tools to train their units. Since the unit chain of command will provide the large majority of trainers for simulations-supported training exercises, this impacts on the quality of simulations events. Given the course length constraints in the institutional Army, we do not see that this type of training could be added to PME courses to any significant extent. However, an alternative would be to add to the size of simulations training staffs, including FA 57s and CP 36 personnel, in order to perform "train the trainer" functions.

Improving Simulations Capabilities

We discussed constructive simulations capabilities in Chapter Six. It concluded there would be improvement in several areas, including the representation of physical realism within the simulation. However, an important limitation of simulations was in the area of SAF and SAF control. AI capabilities to replicate complexity and realism in the COE, to help plan and prepare for such an exercise, and to provide training analysis and feedback are largely nonexistent today. Moreover, our assessment is that this situation will largely continue until well after initial FCS fielding. This means that the large workload and level of expertise needed to plan, prepare, and execute such an exercise with appropriate realism will essentially remain. Also, to increase quantity, it will be important to minimize the administrative and preparation time required of the units that will be trained.

Developing Effective Training Support Tools

Our assessment of various tools to support the planning, development, execution, analysis, and AARs for training, including for constructive events, appears in Chapter Six. We concluded that a number of different tools could help training developers and trainers in the specific areas of scenario authoring, exercise management and automated data collection, analysis, and briefing slide generation for standard AAR slides. While no single tool will significantly benefit the quantity, quality, or adaptability of the training, the additive effect of the simultaneous development of all tools could be important.

How the Army Can Evolve Current Programs to Cost-Effectively Achieve the Potential Benefits of Constructive Command and Battle Staff Training

Significant progress in improving constructive simulations capabilities requires improvement in all the components of the system, as described above. Because the components are interrelated, and there are many uncertainties about the growth rate of these capabilities, especially for simulations and automated training tools, we think spiral development is the logical process for improvement. Endorsed by DoD as the way to build the future training environment, the spiral development process has been described as the "build a little, test a little" approach. [9]

To leverage these initiatives, we propose that the Army prioritize a more structured process of improving its constructive simulations training capability. The key to this process would be a program of observing, assessing, and analyzing ongoing constructive exercises to determine how to gain the most improvement and achieve an efficient use of resources. What follows is a specification of how this program could work.

- **Observation**. Record the training objectives, training audiences, preparation activities, training support manpower with their sources, composition and organization, training support products used, type of simulations and training tools used, training events schedule, and other features of the type of training conducted and of what was required to conduct the exercise. Conduct interviews or a survey of the training audience and the trainers to get their views on the benefits and limitations of the exercise and specifically how it could be improved.
- **Assessment.** The team observing the exercise should have the operational, training, and technical expertise not only to make valid observations and judgments on training benefit but also to develop lessons learned. Given the subjective nature of these func-

[9] *Department of Defense Training Transformation Implementation Plan*, June 9, 2002, pp. 5–6.

tions, commonality of team approaches and standardized criteria will be key.
- **Analysis.** The data provided by an improved system for observing and assessing training exercises will provide the Army with a better basis for determining how to improve constructive training capabilities, including helping to inform decisions on where to place efforts and how these efforts should be implemented. The data will also allow these improvements to be made with an understanding of unit needs and constraints. Finally, they will allow the Army to harvest the lessons being locally learned to use for Army-wide improvement.

We next address selected areas of potential improvement in the support of battle command training using constructive simulations, and how those improvements might evolve. These areas include knowledgeable training manpower and efficient training methods, techniques, and procedures. Appendix B also contains a description of the process for creating effective simulations and automated training tools.

Training Manpower

Our work indicates that, for the period of FCS spiral-out fielding and for well after the fielding of the FCS-equipped BCTs, improvements in quality and adaptability will come primarily from improving the adequacy of trainers and training support manpower. This requires that the Army:

- Determine the requirements for BCTC and BCTP training support organizations: size, composition, and level of expertise.
- Coordinate and align BCTC responsibilities and organization with those of New Equipment Training (NET) teams.
- Support or expand programs to increase the FA 57 and CP 36 career fields to develop more organic expertise in units for leveraging constructive command and battle staff training.

What is the appropriate amount and organizational structure for training manpower? In Chapter Seven we noted that the current manpower programmed for the BCTC would not provide staffing to support a high level of training effectiveness, similar to that provided by the BCTP "Team C" level of support. On the other hand, during our discussions with unit trainers, we were told that the amount of support provided in BCBST exercises was beyond that really needed for an effective training event. We think the Army should begin with currently programmed BCTC manpower, then apply the process of observing, assessing, and analyzing, as described above, to make informed changes to the initial structure.

Efficient Training Methods and Techniques

As addressed earlier in this section, there is a strong need to develop efficient training methods, techniques, and procedures as part of the solution to improving constructive command and battle staff training.

One place to start would be with useful guides that already exist. The most developed product we found describing constructive simulations-supported leader training was the SBCT CPX TSP. Based on our review of this package, we think that more specific methods, techniques, and procedures would be of great value. For example, in this package the responsibilities of the "white cells" are defined. Further development will also be needed, however; for instance, to use the white cell example, there is little discussion or guidance on how their decisions are made at the level of the NTC Rules of Engagement.[10] Thus, these TSPs could be evolved by a structured program to observe and analyze various simulations-supported events, informally assess training benefits achieved, and discuss what works and what does not with trainers and training support staffs.

Another place to begin would be to look for parallel efforts. For example, to replicate a complex, realistic battlefield given the limitations of the MILES tactical engagement system, the Army undertook an extensive learning process to develop the techniques and procedures it uses today. The lead agents were the CTCs, which developed

[10] A "white cell" is a working group headed by the exercise director and commander of the operations group that makes decisions regarding the course of the training, including adjudication of battle results.

detailed rules of engagement (e.g., for close engagements) and OC techniques (e.g., rules for determining which casualties die of wounds and for ammunition resupply). Not only did the CTCs develop these techniques, the OC "graduates" brought them to the rest of the Army during their subsequent unit assignments.

Conclusions

In this appendix we have argued that improvement in the Army's ability to conduct battle command training by enhancing its constructive training capability is both important and possible. However, this improvement is far more than a matter of improvement in constructive technology and software, at least until well past the 2016 timeframe. For this timeframe, the key to achieving this increased capability will be providing adequate training support manpower, developing effective and efficient training methods and tools, and training leaders to use this capability. We think the benefits could be well worth the efforts needed.

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